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COMSAT Laboratories

VOLUME I - EXECUTIVE SUMMARY

FINAL REPORT

GEOSTATIONARY PLATFORMS MISSION AND PAYLOAD REQUIREMENTS STUDY

TO

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

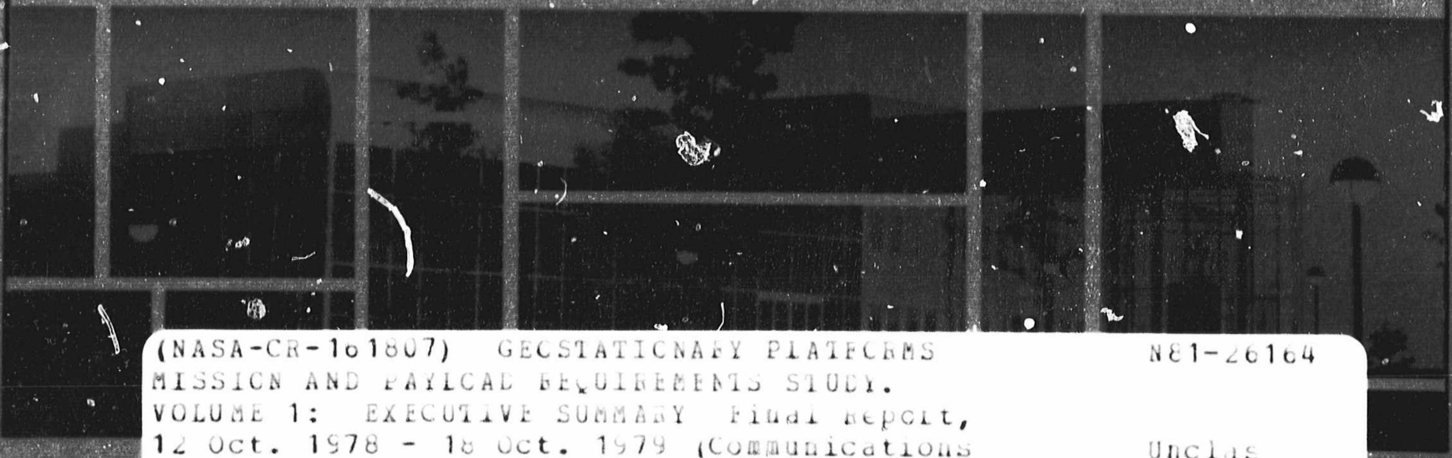
George C. Marshall Space Flight Center

George C. Marshall Space Flight Center, Alabama 35812

UNDER CONTRACT NAS8-33226 TASKS 1,2, AND 3

OCTOBER 30, 1979

COMMUNICATIONS SATELLITE CORPORATION
COMSAT Laboratories, Clarksburg, Maryland 20734



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Volume I—Executive Summary

Final Report

GEOSTATIONARY PLATFORMS MISSION AND PAYLOAD REQUIREMENTS STUDY

Submitted to

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
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October 30, 1979

By

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Foreword

This is the final report for the "Geostationary Platforms Mission and Payload Requirements Study" conducted by the Communications Satellite Corporation from October 12, 1978, to October 18, 1979, under National Aeronautics and Space Administration (NASA) Contract No. NAS8-33226. The NASA study director was W. T. Carey, Jr. of the NASA George C. Marshall Space Flight Center at Huntsville, Alabama.

Volume I is the Executive Summary, and Volume II describes the work performed. During the contracting period, monthly letter-type reports and two extensive midterm reports were filed.

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1. INTRODUCTION

1.1 WHY A LARGE SPACE PLATFORM?

Large space stations (geostationary platforms or orbital antenna farms) offer the potential of lowering communications costs through the economy of scale that results from combining multiple satellite missions onto a single large satellite or platform. These platforms, which are placed into geostationary orbit, are characterized by their large aperture antennas interconnected by a switch (or switches), diversity of missions (communications and other), and the possibility of adding or replacing portions to incrementally modify or update the payload or platforms in orbit. By their very nature, these are characteristic of a new shuttle-launched class of satellites.

2. CONTRACT OBJECTIVES

The contract specified that the following tasks be performed (see Section 3 of the Technical Volume for further details):

a. Determine the optimum locations for geostationary platforms.
b. Determine potential missions and their characteristics.
c. Contact potential users for their comments.
d. Determine the interface requirements between the missions and the geostationary platform.
e. Prepare a payload databook.
f. Conduct antenna tradeoff studies.

2.1 STUDY LIMITATIONS

The underlying purpose of this study was to identify time-phased missions and payloads for potential accommodation on geostationary platforms and to identify the engineering requirements placed upon the platform housekeeping elements by selected payloads. Subsequently an investigation contract for structural studies would be awarded. The "Geostationary Platforms Mission and Payload Requirements Study" contract did not examine non-payload aspects such as structural design or propulsion stages, and non-engineering factors such as flight operations or regulatory, statuatory, and institutional aspects. These and other topics are the subject of the recently awarded NASA Marshall Space Flight Center contract (NAS8-33527) with General Dynamics.

3. PURPOSE OF THE STUDY

This study examined the possibility of using a few platforms in place of many small satellites to provide communications and other services. It is based on the original "Orbital Antenna Farm" conceived by W. L. Morgan and B. I. Edelson of the Communications Satellite Corporation [1] in 1975, and subsequent NASA studies [2].

The purpose of this study was to identify and define time-phased missions and payload that may be accommodated by several geostationary platforms placed at high-traffic locations around the globe (defined as covering the United States; North, Central, and South America; and Western Europe). However, it was not the intent to determine the economics, mechanical feasibility, institutional propriety, assembly techniques, or overall satellite configuration of geostationary platforms. NASA intended to subsequently use the data developed under this contract to perform tradeoff studies and analyses of potential geostationary platform approaches and concepts to determine an optimum geostationary platform concept.

3.1 PLATFORM CONCEPTS

Platforms will be transported to low orbit by Shuttle. One or more launches will contain the basic geostationary platform. Deployment and assembly of sections of the platform, as well as some tests, will be performed in low earth orbit. Upper stage vehicles (e.g., Centaur, I.U.S., or the NASA-MSFC-OTV) will be used to transfer the contents to the geostationary orbit. The platforms may have an open-ended lifetime through periodic replacement of life-limited components (e.g., fuel and flywheels)

and retrofit of technology-limited devices (e.g., transponders). The basic platform will provide electric power, telemetry, station-keeping, coarse pointing, and thermal control for the individual mission payloads.

3.2 END USE

Typical payload missions have been defined in terms of frequencies, power, beam patterns, interconnections, support requirements, and other characteristics. This study reviewed a number of potential missions, consulted with leaders in industry, determined the platform interface requirements and coordinated with various NASA centers and headquarters.

3.3 USER SURVEY

The user survey, which employed a novel card system, resulted in data on individual satellite system requirements of the future. The data included information on the earth station figure-of-merit, the satellite antenna coverage, the amount of traffic, and the date of substantial service via satellite for 31 service categories. The participants were asked to consider individual missions. Each organization was given a copy of an article by Jaffe, Fordyce, and Hamilton entitled, "A Switchboard in the Sky Concept for Domestic Satellite Communications" [2].

Subsequently, the 31 possible missions were consolidated (with NASA-MSFC's guidance) into 12 missions, of which three were considered duplicates of the study conducted in parallel with the Aerospace Corporation [3] under Contract NAS8-32281. In these three cases, COMSAT was directed to use the Aerospace Corporation models.

4. APPROACH

4.1 MISSIONS

Table 4-1 shows the three lists of missions considered in this study. Column 1 contains the service categories given in the Statement of Work as potential subjects for investigation. The list of categories for the user survey is in column 2. The final list is a combination of columns 1 and 2.

Although all of the suggested services were included, several have been combined into a more generic form to increase manageability. Only one, "standard time and frequency," was dismissed because of lack of interest. The deletion of this small mission affected the total geostationary platform mass and power budgets by less than one percent.

4.2 INDUSTRIAL PARTICIPATION

For the user survey (Task 1.3), a list of 31 potential missions (compiled under Task 1.2 was presented personally to the vice presidents of the leading telecommunications suppliers (carriers, programmers, users, and manufacturers). An attempt was made to select both advocates and antagonists of the mission to provide an appropriate cross section of the industry. The results of the survey were used to configure missions, subject to NASA direction in Task 1.2a (see Figure 4-1). It was then possible to synthesize the platform interface requirements (Task 2a).

Table 4-1. List of Missions

Initial List (from Statement of Work)	User Survey List	Final Model List
Communications		
Trunking Systems and Fixed Networks	Trunk Telephony International Private Line	High-Volume Trunking* International
Mobile Systems		
Maritime-Mobile	Maritime	Mobile, Sea
	Search & Rescue	Mobile, Sea
Aeronautical-Mobile	Aeronautical	Mobile, Air
	Search & Rescue	Mobile, Air
Land-Mobile	Land-Mobile	Mobile, Land
	Bush Voice	Mobile, Land
Distribution Systems	CATV	Broadcast*
	Educational TV	Educational TV
	Data	Direct to User*
	Electronic Funds Transfer	Direct to User*
	Electronic Mail	Direct to User*
	Electronic Office	Direct to User*
	Telelibrary	Direct to User*
	Paging	Direct to User*
	Personal Communications	Direct to User*
	Public Safety	Direct to User*
	Remote Printing	Direct to User*
	Telehealth	Direct to User*

*Adopted from the Aerospace Corporation Study.

Table 4-1. List of Missions (continued)

Initial List (from Statement of Work)	User Survey List	Final Model List
Data Collection	Data Collection	Data Collection
Broadcast Services	Direct TV Broadcast	Direct TV Broadcast
	Network TV	Broadcast*
	Teleconference	Broadcast*
Intersatellite Communications		
Geostationary	Intersatellite Links	Inter-platform Links
Deep Space	Intersatellite Links	TDRS
Other Applications		
Navigation	Navigation	(intergrated into mobile)
Disaster Warnings	Public Safety	Direct to User*
Earth Resources	Earth Exploration	Data Collection & TDRS
Meteorology	Weather	Severe Storm Research
Standard Time & Frequency	Time & Frequency Standards	(dropped)
Space Tracking	Low Orbit Relay	TDRS

*Adopted from the Aerospace Corporation Study.

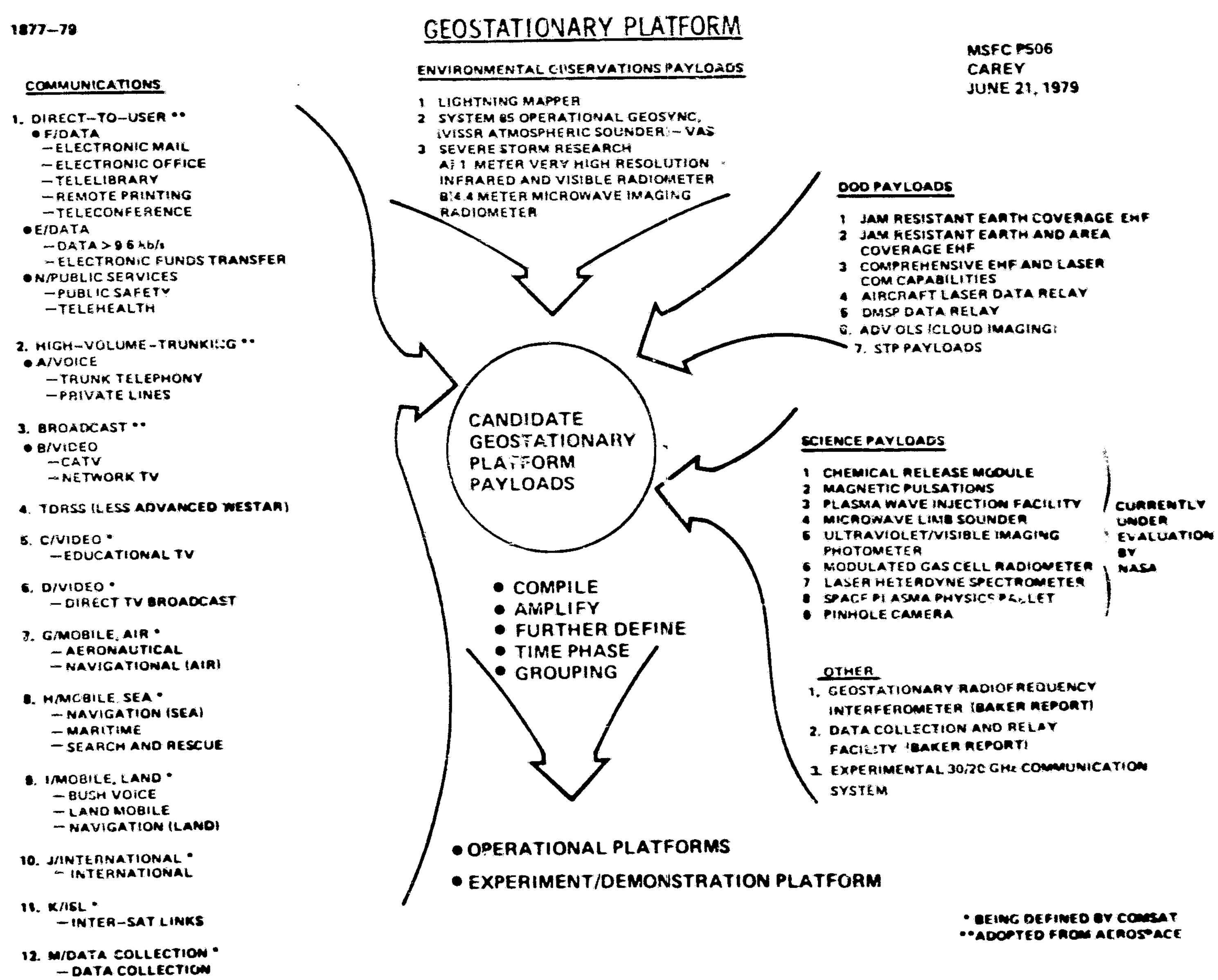


Figure 4-1. Payloads Selected

The formal user survey, which was personnally conducted, involved over 25 participants. In addition, informal contacts were conducted with both U.S. and European contacts. The survey covered all 31 mission categories. The users were informed that the intent was to identify potential services which could be provided by a large communications platform and the platform interfaces. They were informed that the purpose of this study being conducted for NASA was to determine the technical requirements their needs would impose upon a platform. They survey was conducted using sets of cards which contained choices of values for each parameter or the name of a mission.

4.3 MISSION TIMING

Thirty-one category cards were distributed along with four date cards (1979, 1984, 1989, and "unknown"). The user was asked to sort the cards by the inception date of substantial commercial service and to place them in each data deck by priority. In this manner, the more vital categories were separated from the less interesting. Table 4-2 shows the top ten missions by 1989.

4.4 SPACE-TO-EARTH LINK REQUIREMENTS

Next the type of earth station envisioned to provide each service in the 1980's (the NASA-provided time frame of the initial platform) was identified. With knowledge of the earth station's figure-of-merit (G/T_s), the service's bandwidth, the signal-to-noise requirements, and the modulation method, the satellite's equivalent isotropically radiated power (e.i.r.p.) can be determined.

Table 4-2. Satellite Missions Selected in Survey

Top 10 Mission Selections by 1989
Network TV Services (most likely)
Cable TV Services
Data (greater than 9.5 kbit/s)
Trunk Telephone
Earth Exploration
Electronic Mail
Electronic Office
Teleconference
Educational TV Services
Electronic Funds Transfer

4.5 COVERAGE FROM THE GEOSTATIONARY ORBIT

Knowledge of the e.i.r.p. is not sufficient to define the transponder adequately to determine the platform interfaces. Therefore, the users were offered a wide choice of satellite antenna coverage patterns ranging from global to cluster beams. Each category card was matched with a coverage pattern.

The selected locations are shown in Table 4-3.

Table 4-3. Principal and Alternate Platform Locations

Selected Locations		
Regional Coverage	Longitude	
	Prime	Alternate
North America	120°W	116°W
South America	80°W	60°W
(North & South America)	(100°W)	(97°W)
Western Europe	0°E	5°E

4.6 TRANSPONDER RF POWER OUTPUT REQUIREMENTS

The transponder power requirement at the antenna input may be determined when the e.i.r.p. and antenna pattern (which translates to satellite antenna gain) are known.

4.7 EARTH-TO-SATELLITE LINK CAPABILITIES

In a similar manner, the up-link G/T_s may be determined, since the antenna gain, G, is now known and a typical satellite, T_s, can be selected based on experience. With knowledge of the up-link G/T_s, the earth station transmitter may be specified for a given margin and bandwidth.

4.8 TRANSPONDER CHARACTERISTICS

Identification of the characteristics of the platform's transponder, its antenna, its beamwidth (hence, the antenna pointing accuracy), and the DC power (using the DC to RF conversion efficiency) is now possible for an individual mission's transponder. Knowing the DC and RF losses permits computation of the thermal load.

4.9 TRAFFIC

The next question concerning the number of transponders was not asked directly. (Many users admitted they had no idea how many will be needed; others would not reveal corporate plans.) However, users were asked what portion of the total communications

marketplace (for each of the categories) will be served by satellites in 1984. Other NASA studies [4] have identified total markets, and this survey then provided estimates of the submarket share provided by satellites.

4.10 USER SURVEY CONCLUSIONS

The results of this survey are given in the Appendix of this volume.

5. PRINCIPAL RESULTS

Payloads were selected on the basis of the user survey, industry contracts, and NASA direction. The final model list is shown in Table 4-1. The resulting spacecraft configuration considering the earth and space segments is given in Tables 5-1a and 5-1b.

These tables give the frequency, number of transponders, bandwidth, RF power, system noise temperature, mass, and DC power levels for each transponder. The antenna requirements are also specified. Both the Aerospace Corporation (Table 5-1a) and the COMSAT (Table 5-1b) results are given in a consistent format.

Appendix A of Volume II extensively describes each of the payloads assigned to COMSAT. One of these missions (the aeronautical mobile satellite service) has been included in this volume as an example. Each of these models consists of a statement of the mission objectives, the methodology, a list of the users, a description of the mission payload, the space segment, the platform support requirement, and the matching terrestrial facilities. A table of the end-to-end parameters completes each mission. This table, patterned after the ATS-F Databook format, provides a full specification of each link. Additional material includes the number of beams, the output backoff, and the sum of the carrier-to-noise ratio and the margin.

Table 5-1a. Summary of Payload Configurations[a]

Parameters	Direct-to-User System	High-Volume Trunking System	Broadcast
Transponders			
Frequency Band	Ku	C	Ku
No.	480	200	54
Burst Rate (Mbit/s QPSK)	64	256	64
P.A. RF Power (W)	1	0.05	10
NF (FET preamp) dB	5.5	3.4	5.5
kg[c]	1130	340	275
DC Power (W)	3700	940	2910
Antennas			
Type	Center Fed Cassegrain	Center Fed Cassegrain	Offset Fed[d] Feed Plane
Diam of Refl. (m)	5 (3 reflectors)	30	1.5
Gain (dB)	54.5 (up-link) 53 (down-link)	59 (up-link) 56 (down-link)	~34
Sidelobe Objective (dB)	28	28	Not Critical
Required Accuracy Pointing	0.03°	0.01°	0.01°
kg	96	250	9
Switch-Fast Matrix			
Size	630 x 630	240 x 240	50 x 50
Matrix			
kg[c]	240	36	4.8
DC Power (W)	4000	400	40
Total Wt kg	1666	626	289
Total DC Power Watts	7700	1340	2950

[a] Source Aerospace Corporation.
[b] 40 transponders operated at 512 Mbit/s using higher level PSK.
[c] Includes 20 percent additional for redundancy and on-orbit servicing.
[d] Using polarizaiton-sensitive sub-reflector.

Table 5-1b. Summary of Additional Communications Payloads

Parameters	Tracking & Data Relay 4	Educa-tional TV 5	Direct TV Broadcast 6	Air 7	Sea 8	Land 9	Inter-national 10	Inter-Platform Links 11	Data Collection 12
				Transponders					
Frequency Band[a] (GHz)	2.0-15.0	2.5-14.5	0.7-14	1.5-5	1.5	0.9	4-30	55	0.4
Number (active)	6	32	8	3	4	19	12	1	1
Bandwidth (MHz)	110	17.5	40	400.4	0.2-0.6	2-17	40-100	500[b]	1
RF Power (rated W)	1.6-50	6	100	5-90	2-70	60-560	to 50	65-300[b]	0.3
T_s (K)	450	525	371	354	1000	200	377-920	600	1000
Mass (kg)	70.3	424	362	128.9	52	1644[c]	123[c]	48[b]	17.5
Power (W)	444	368	2064	869	437	7920[c]	425[c]	308[b]	18
				Antennas					
Type	TDRS[d]	Offset	Centerfed	Helical	Helical	—[e]	Several	Special	—[e]
Diameter (m)[f]	0.7-18	2x2.8	7.5x10	Array	14 m	—[e]	0.75-5.3	3	11
Gain (dBi)[f]	24-55	44.3	44.3	19	44.3	44.3	44.3	—[b]	30
Sidelobe Objective (dB)	TDRS[d]	30	30	30	30	30	30	—[b]	n.a.
Pointing Accuracy (deg)	TDRS[d]	0.1	0.1	0.1	0.1	0.1	0.1	b	0.1
Mass (deg)	31	54.8	7.3[e]	23.6	7	45[e]	53	40	25[e]
				Totals					
Mass (kg)	101.3	478.8	369.3	152.5	59	1689[c]	178[c]	88[b]	42.5
Power (W)	444	368	2064	869	437	7920[c]	425[c]	308[b]	18

[a] Subject to revision as the result of GWARC-79.
[b] See Technical Volume.
[c] North America.
[d] Tracking & data relay satellite model.
[e] Uses HVT reflector
[f] Largest.

Mission 7. Mobile, Air

(Example of detailed data on each of the payloads assigned to COMSAT provided in Appendix A of Volume II.)

Mission Number: 7

Mission Name: Mobile, Air

Objective: Provide communications and navigation to/from commercial aircraft.

Methodology: Links to/from commercial aircraft are provided at 1.6/1.5 GHz in internationally allocated aeronautical mobile satellite bands. At the geostationary platform, these channels are converted to the 5-GHz band (as used by Aerosat) for connection to air traffic control and navigation centers.

User Community: Airlines and the national aerospace administrations (e.g., F.A.A.).

Mission Payload Description

Three 10° coverage beams illuminate the earth.

The air traffic control centers are connected via a global beam at 5 GHz to permit full interworking. Alternatively, this link could be handled by the onboard satellite switch in the direct-to-user service.

Navigation, search and rescue services are connected at the aircraft and earth station ends.

This scenario closely follows the protocols jointly agreed to by European, U.S., and Canadian interests and the resulting memorandum of understanding.

Spage Segment Description*

Antennas: The antennas at 1.6/1.5 GHz use a fixed phased array of helical elements. The 5-GHz services are provided via a 0.2-m horn. There are two 0.2-m horns per platform.

*The equipment is based on the Aerosat requirements.

Receivers: Each geostationary platform has four dual 354 K receivers.

Transmitters: 5 W and 90 W at 1.5 GHz, and one pair of 10 W at 5.125 GHz.

Frequency, up-link (GHz):
1.5 and 5.125 (aircraft to geostationary platform)
5.880 (land to geostationary platform)

Frequency, down-link:
1.6 and 5.880 (geostationary platform to aircraft)
5.125 (geostationary platform to land)

Harmonics: Fourth harmonic of 1.5 GHz falls in 6-GHz receive band, fifth harmonic falls in 7-GHz band, and seventh harmonic falls in 11-GHz band. Troublesome harmonics of 5.125 GHz are the second (11-GHz band) and third (KSA up-link).

Antenna Surface Tolerance: Not applicable for 1.6/1.5-GHz global helix. A loss of 0.7 dB results from a 7-mm rms at 1.6 GHz; and 0.4-mm rms at 5.88 GHz results in a loss of 0.04 dB.

Candidate Antenna Types: Helical arrays and front-fed reflectors using rigid and mesh deployed reflectors. (The 5-GHz global beam may use a horn antenna.)

e.i.r.p. (dBW): 38.0 (per channel) at 1.5 GHz and 20.1 at 5.125 GHz.

G/T_S (dBi/K): -11.3 at 1.6 GHz and -16.5 at 5.88 GHz.

Platform Support Requirements

DC Input (W): 869

RF Radiated (W): 176

Heat Radiated (W): 693

Thermal Constraints (C): 0 to 40

Weight Estimate (of transponders): 128.9

Weight Estimate (of antennas): 23.6 kg

Telemetry or Data Link Requirements (approximate): Power supply (2), status (per transponder) = 21

Commands (approximate): On/off, redundant switch (per transponder) = 21 (total)

Platform Location (west longitude):
North America
South America
Western Europe

Field of View: Global

Antenna Pointing Accuracy (deg): A $\pm 0.1°$ pointing accuracy results in a worst case loss of 0.06 dB for the 10° beams.

Contamination: None

Stationkeeping (deg): Not applicable because of hemispheric aircraft beams and tracking earth stations.

Aircraft and Earth Station Descriptions

Up-link

Frequency (GHz)
- Aircraft: 1.6
- Land station: 5.88

Bandwidth
- Aircraft: 80 kHz
- Land station: 400 kHz

Modulation/multiple access: SCPC/FM

Transmitter power (W per channel)
- Aircraft: 220 W
- Land station: 50 W (for 400 kHz)

Antenna diameter (m)
- Aircraft: 0.8
- Land station: 7

Down-link

Frequency (GHz)
- Aircraft: 1.5
- Land station: 5.125

Bandwidth
- Aircraft: 80 kHz
- Land station: Up to 400 kHz

Modulation/multiple access: SCPC/FM

System noise temperature (K)
- Aircraft: 354
- Land station: 195

Antenna diameter (m)
- Aircraft: 0.8
- Land station: 7

$GT/_s$ (dBi/K)
- Aircraft: -7.4
- Land station: +26

Mission 7. Mobile, Air (G) Transmissions
Link Data

Link	Nominal Frequency (GHz)	RF Beam-width (kHz)	Transmit Power (W)	Actual e.i.r.p. (dBW)	Antenna: Transmit: Diameter	Antenna: Transmit: Field of View (deg)	Antenna: Transmit: Peak Gain (dBi)	Antenna: Transmit: Field of View Gain (dBi)	Antenna: Receive: Diameter	Antenna: Receive: Field of View (deg)	Antenna: Receive: Peak Gain (dBi)	Antenna: Receive: Field of View Gain (dBi)	G/T_s (dBi/K)	No. of Beams	Output Backoff (dB)	C/N + M(dB)	Remarks	T_s (K)
Down	1.5505	80	90	38.0	--[a]	10[b]	19.5	16.4	0.8	17.0	19.6	16.6	-7.4	3	2	15		354
Down	5.125	400	10	20.1	0.2	--[c]	19.1	15.5	7.0	0.6	49.0	48.9	+26.0	1	2	19		195
Up	1.6515	80	220	38.0	0.8	17.0	19.6	16.6		10[b]	19.5	16.4	-11.3	3	0	17		600
Up	5.880	400	50	63.3	7.0	0.6	49.0	48.9	0.2	--[c]	19.1	15.5	-16.5	1	0	20		200

[a]Helix.
[b]Shaped.
[c]Global.

One of the critical technology items is the antenna. Table 5-2 tabulates the communications antenna requirements. The requirements for these antennas are compared to the existing state-of-the-art for large antennas using background material derived from a NASA-JPL report [5]. Figures 5-1 and 5-2 illustrate a basic dilemma of beam clustering. If the 0.35° patterns of the Aerospace Corporation study [3] and the Western Union traffic distribution [4] are used, then a few beams (e.g., those covering New York/Pennsylvania/New Jersey) carry a disproportionate share of the total U.S. traffic. (The numbers denote the percent of the U.S. traffic devoted to voice, data, and video services in each geographic district). Other 0.35° beams covering the Rocky Mountains and the deserts have very little traffic. Traffic from the heaviest node (New York City and environs) was divided among three beams so that much of the short haul traffic (New York to Philadelphia, New York to Boston, and New York to Pittsburgh) could be contained within a single beam to avoid the need for onboard beam-to-beam switching of at least some of this heavy traffic.

Table 5-2. Antenna Requirements (Communications)

Mission	Beams	Width (°)	Diameter (m)	Frequency (GHz)	Polarization	Power RF	Power DC	Point	Type[a]
1. Direct-to-User[b]	60	0.35±	3 @ 5	14 12 (Ku)	2	0.7 (ea.)	3700	0.03	FA CP
2. High-Volume Trunking[b]	20	0.106/0.165	1 @ 30	6 4 (C)	2	0.05	940	0.01	FA CP
3. Broadcast & Video Distribution[b]	7	Time Zone	1.5	17 13 (Ku)	2	10	2910	0.10	FA OFP
4. Tracking & Data Relay	Many	0.3 to 4.5	2 to 5	2 to 15 2 to 13	2	1.6 to 50[c]	444[c]	0.10	FFP & FA
5. Educational TV	4	3 x 4	2 x 2.8	14 2.5	2	6	92[c]	0.10	RA CP
6. Direct TV Broadcast	4	3 x 4	7.5 x 10	14 [illegible]	2	100	2064	0.10	RA FFP, MY
7. Mobile, Air	4	0.6, 17	0.8, 7	1.6 to 6 1.5 to 5	2	50 to 220	869	0.10	HA FFP HO
8. Mobile, Sea	4	1, 17	uses 30 m (part)	1.6 to 6 1.5 to 4	2	2.0 to 60	437	0.10	HA, HO, FFP
9. Mobile, Land	10-19	1	uses 30 m (part)	0.9 0.9	2	60 to 560	2080 to 7920	0.10	MY, HA
10. International	12	1	1.1 to 5.3	6 to 29 4 to 18	2	0.01 to 50	123 to 598	0.10	FFP, OFP
11. Inter-platform links	2	0.13	3	55 55	1	130[c]	680[c]	0.03	FFP
12. Data Collection	1	5	11	0.4 DTU	1	0.05	18	0.10	MY/FFP

[a]FA = Feed array
FFP = Front-fed parabola
CP = Cassegrain parabola
OFP = Offset fed parabola
HO = Horn

PA = Phased array
RA = Reconfigurable array
MY = Multi-yagi type array
HA = Helix array

[b]Per NAS8-33281.
[c]Will increase per NASA direction letter.

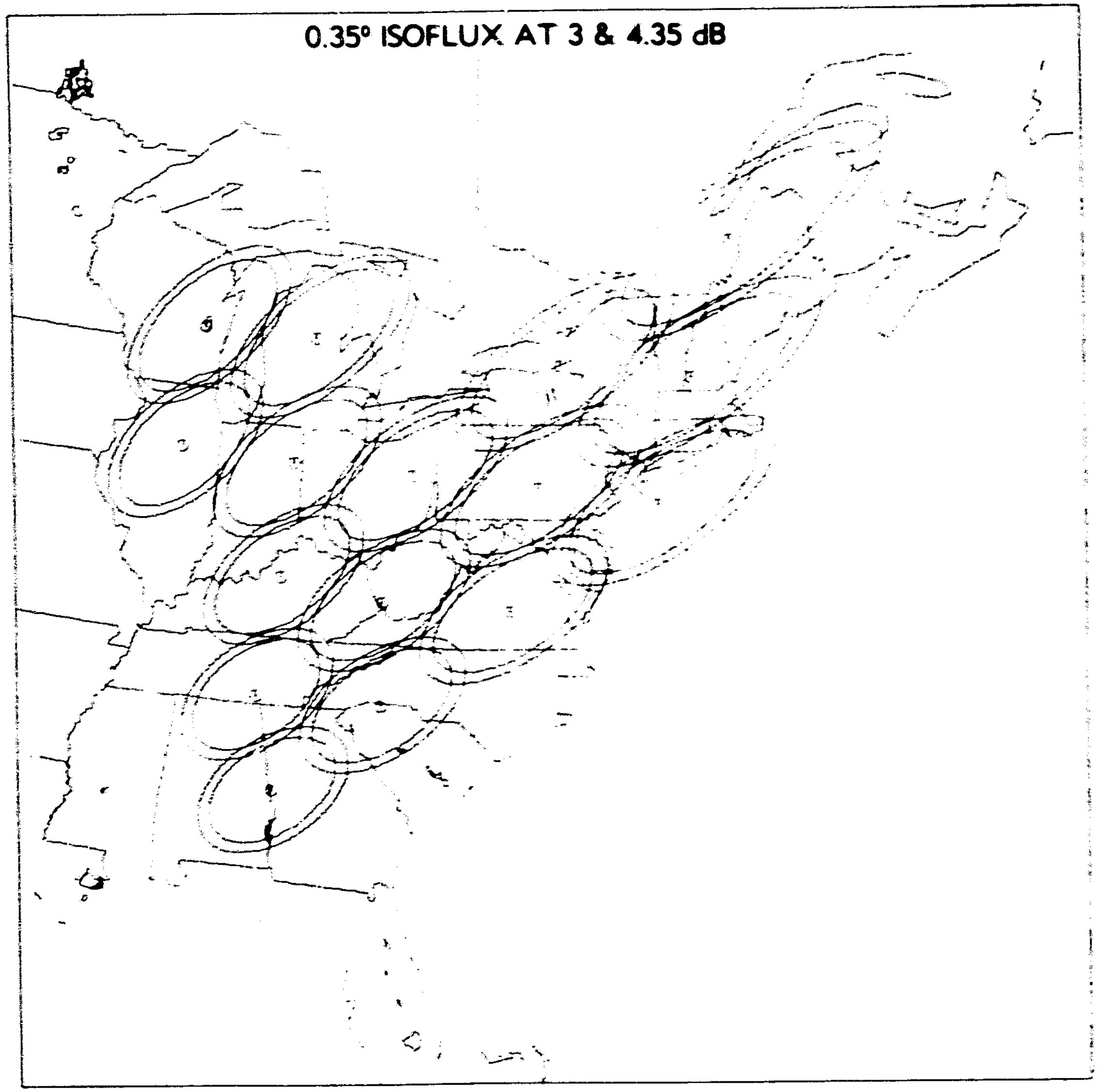


Figure 5-1. Eastern U.S. Coverage

U.S. GEOGRAPHICAL DISTRIBUTION OF TRAFFIC REGIONS. 1990

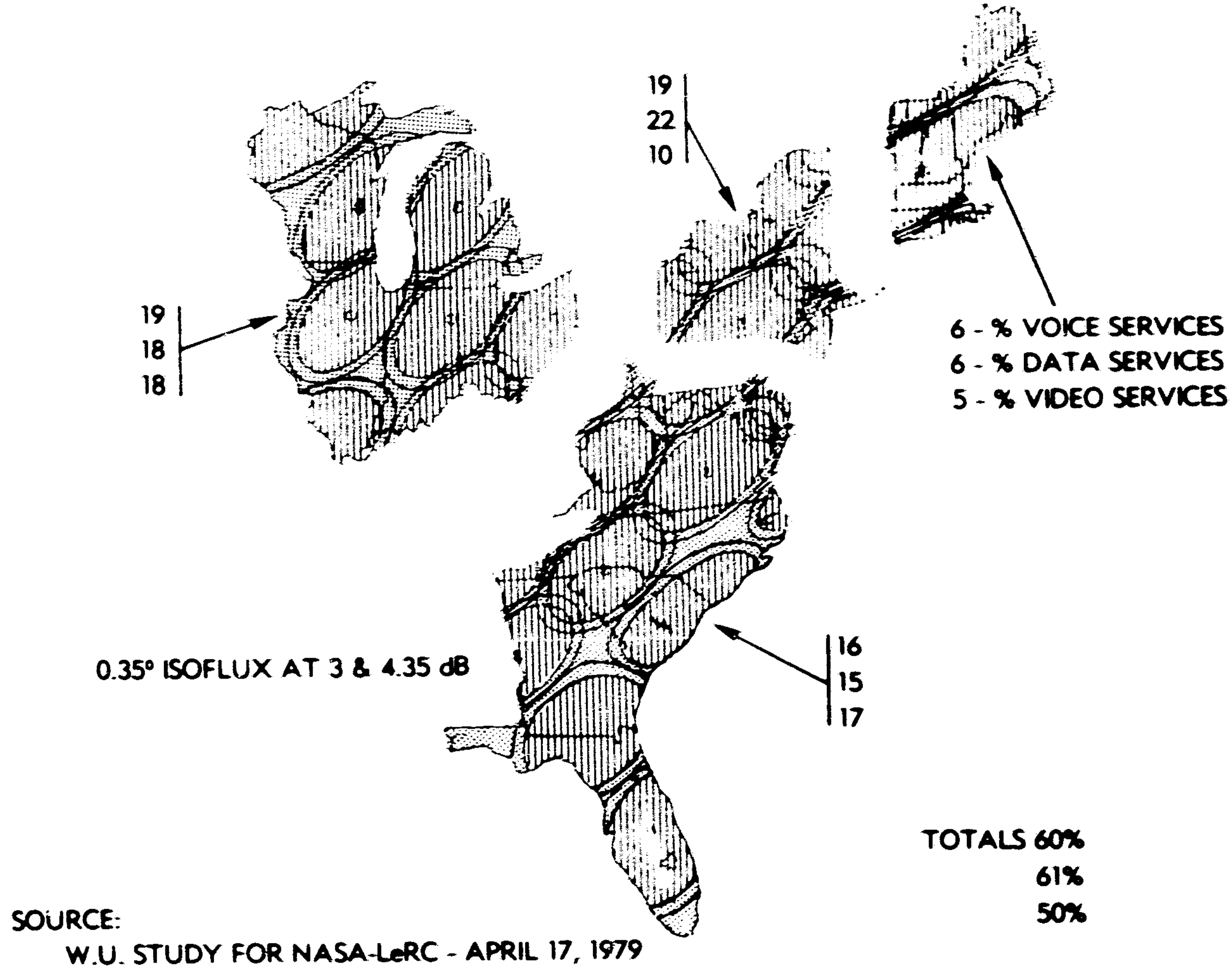


Figure 5-2. Traffic Per Beam

6. OVERALL PLATFORM REQUIREMENTS

The individual support requirements identified in the mission models (Appendix A of Volume II) have been combined to define the overall platform requirements which are summarized in Table 6-1.

Table 6-1. Platform Interface Requirements

Power Requirements (Approx.)	20 kW
Thermal Dissipation (Approx.)	16 kW (th)
Attitude Control (Gross*)	±0.1°
(Fine RF)	±0.03° and ±0.07°
Reflector Surface Structure (Stability)	0.018 to 5.5 cm rms
Stationkeeping (East-West)	±0.1°
(North-South)	±0.1°

* Measured at antenna roots.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 ADVANCED ANTENNA DESIGNS

Studies in the antenna area have indicated that additional work is needed on multibeam antennas using wide scan angles. The shape of the individual beam patterns varies over the area to be covered (contrary to simplistic hexagonal presentations), and interference from the summation of the individual sidelobe levels can be significant. These studies suggest that, by breaking the area to be covered into different parts (e.g., a nation into several regional markets using various independent reflectors), the scan angle may be restricted to maintain pattern shape and to reduce sidelobe levels. Since these topics are being addressed in other studies [6,7], these results should be integrated into any follow-on work.

7.2 ATTITUDE CONTROL AND STRUCTURAL RIGIDITY

Occasionally, the antenna and radiometer beam pointing requirements necessitate subplatforms even if an overall platform pointing accuracy of 0.1° can be maintained. The use of light rather than hexagonally rigid structures [2] will increase flexibility; therefore, the platform pointing errors may be greater. Also, under thermal stress conditions, the long booms may warp. This study has successfully identified individual antenna beam pointing requirements; subsequent studies (already under contract [8]) have been tasked to consider these tradeoffs which involve platform structure vs subplatform mass, power, and reliability.

8. REFERENCES

[1] B. I. Edelson and W. L. Morgan, "Orbital Antenna Farms," Astronautics and Aeronautics, Vol. 15, No. 9, September 1977, pp. 20-29.

[2] L. Jaffe, S. Fordyce, and E. C. Hamilton, "A Switchboard-in-the-Sky Concept for Domestic Satellite Communications," Prepared for NASA by Baker Development Corporation, NASA W-14211, October 17, 1977.

[3] F. E. Bond, "Communication Architecture for Large Geostationary Platforms," International Astronautical Federation XXXth Congress, Munich, September 17-22, 1979, Paper IAF-79-F-300.

[4] "18/30 GHz Communications System Service Demand Assessment," studies conducted by Western Union Telegraph Co. and U.S. Telephone & Telegraph Corporation for NASA-Lewis Research Center, 1979.

[5] R. E. Freeland, "Industry Capability for Large Space Antenna Structures," NASA-JPL, May 2, 1978 (Report 710-12).

[6] R. Donavan, "Applications Technology Platform," JSC Contract NASA 15718, Rockwell International, September 1979.

[7] Multibeam studies are being conducted for NASA's Lewis Research Center by Case-Western Reserve University and the University of Southern California.

[8] NASA-MSFC-RFP for NAS8-33527.

APPENDIX

Results of User Survey

CONDUCT OF THE GEOSTATIONARY PLATFORM MISSION AND PAYLOAD REQUIREMENT STUDY

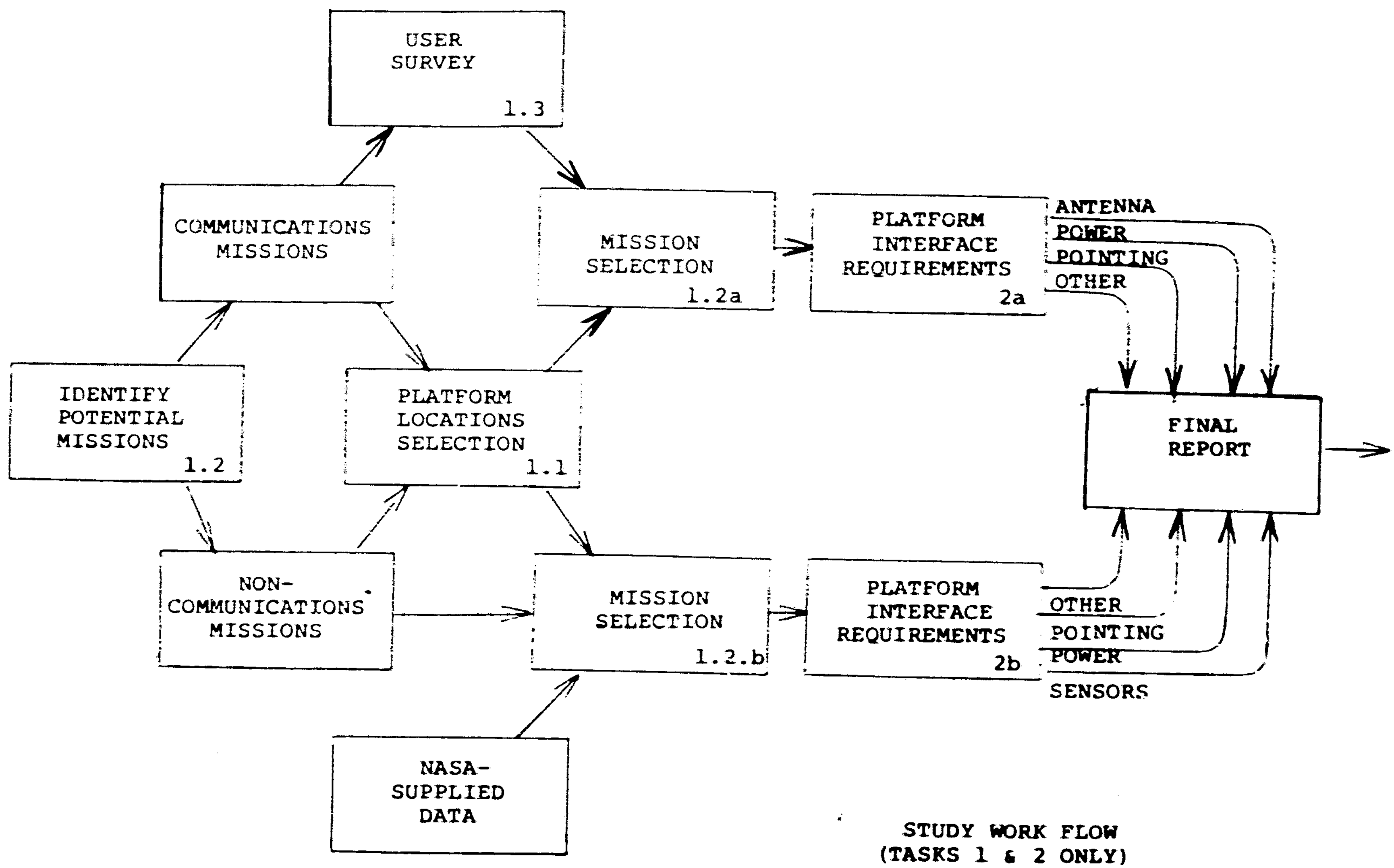
THE CONTRACT REQUIRED THE COMMUNICATIONS SATELLITE CORPORATION TO PERFORM THE TASKS SHOWN ON THE FACING PAGE.

COMSAT IDENTIFIED 31 POTENTIAL MISSIONS FROM A MUCH LARGER LIST. THIS LIST WAS SUBMITTED TO POTENTIAL USERS OF A GEOSTATIONARY PLATFORM FOR THEIR REVIEW AND COMMENT. THE RESULTS OF THIS SURVEY ARE CONTAINED IN THIS DOCUMENT. IN ADDITION TO THE SELECTION OF MISSIONS, THE SURVEY ALSO INCLUDED OPPORTUNITIES FOR THE USERS TO INDICATE THE TYPE OF EARTH STATION, THE COVERAGE PATTERN, THE DATE OF SERVICE INCEPTION, AND THE AMOUNT OF TRAFFIC IN 1984.

THE RESULTS OF THIS INFORMATION ARE BEING COMPILED IN THE FINAL MISSION SELECTION AND IN THE DEFINITION OF THE REQUIREMENTS OF THESE MISSIONS UPON THE PLATFORM. THESE REQUIREMENTS INCLUDE ANTENNA SIZING, POWER REQUIREMENTS, POINTING, TELEMETRY, STATIONKEEPING, ETC. A PARALLEL PATH IS SHOWN IN THE LOWER PORTION ON THE ADJACENT PAGE. NONCOMMUNICATIONS MISSIONS WERE DEFINED BY NASA AS 1 AND 4.4 M RADIOMETERS OPERATING IN THE VISIBLE & IR AND 108 & 180 GHz REGIONS FOR METEOROLOGICAL PURPOSES.

THIS REPORT IS PREPARED AS A FEEDBACK TO THE PARTICIPANTS IN THE SURVEY. INDIVIDUAL PARTICIPANTS ARE NOT AND WILL NOT BE IDENTIFIED AS PER THE CONTRACT WITH NASA/MSFC.

THE SURVEY WAS DESIGNED AND CONDUCTED BY WALTER L. MORGAN OF COMSAT LABORATORIES IN CLARKSBURG, MARYLAND. FOR FURTHER INFORMATION PLEASE CONTACT HIM AT 22300 COMSAT DRIVE, CLARKSBURG, MD. 20734, (301-428-4204).



STUDY WORK FLOW
(TASKS 1 & 2 ONLY)

OBJECTIVES OF THE USER SURVEY

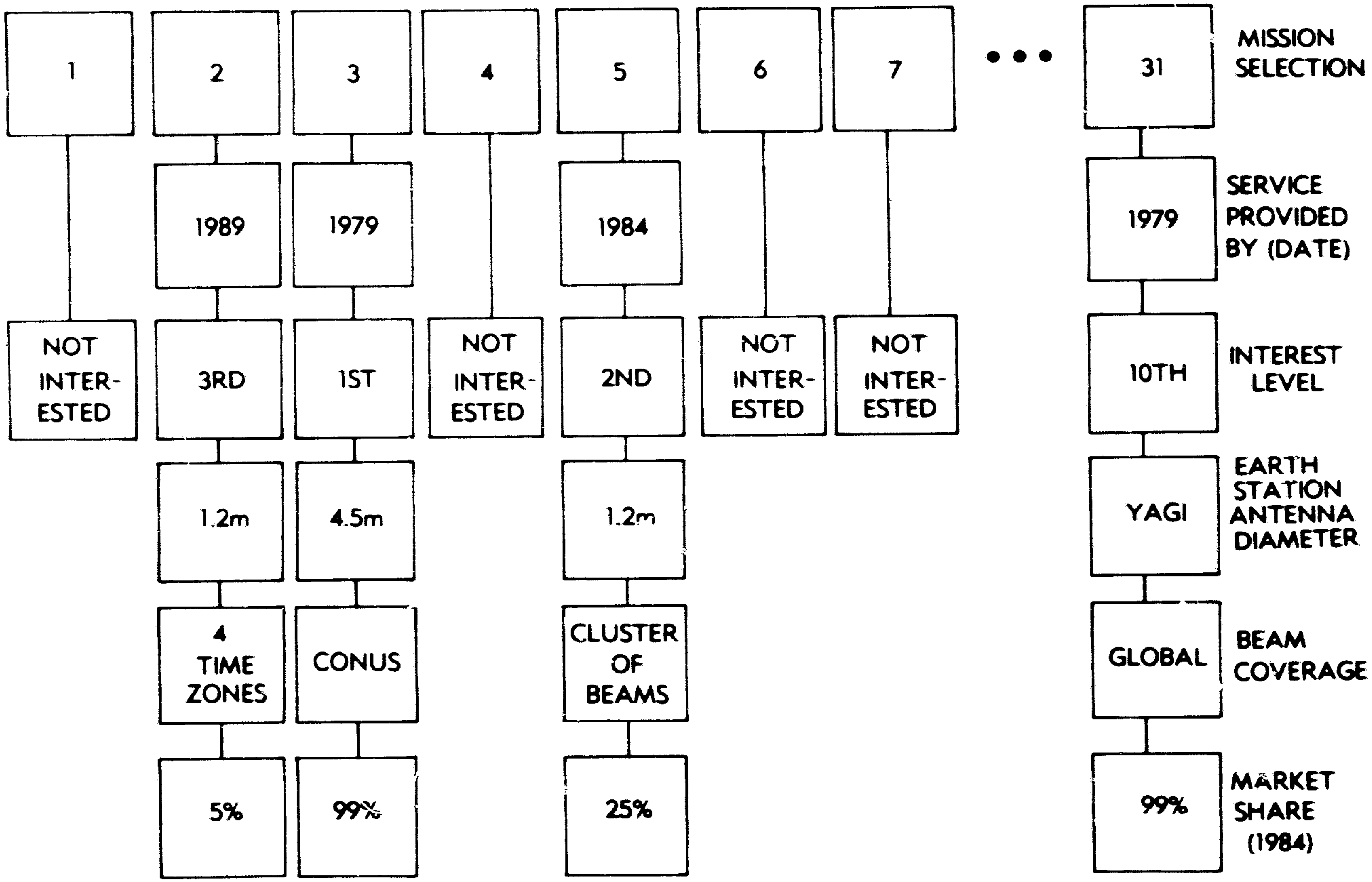
A SERIES OF CARDS WAS MADE CONTAINING THE 31 MISSIONS (SHOWN ON PAGES 17 & 18), BEAM COVERAGE PATTERNS, EARTH STATION SIZES, MARKET PERCENTAGES, AND THE DATES (1979, 1984, 1989, OTHER).

USING COMBINATIONS OF THESE CARDS THE USER WAS ASKED TO DEFINE THE CHARACTERISTICS OF THE SERVICES. THIS WAS DONE INITIALLY BY DISPLAYING THE 31 MISSION CARDS AND THE 4 DATE CARDS AND ASKING THE PERSON (OR PERSONS) BEING SURVEYED TO SORT THE MISSIONS BY DATES. THIS ESTABLISHED THE TIME FRAME WHEN SUBSTANTIAL SERVICE WOULD BECOME AVAILABLE TO THE PUBLIC. HAVING COMPLETED THIS TASK HE WAS THEN ASKED TO RANK THE MISSIONS BY IMPORTANCE IN EACH OF THE 4 DATE PILES. AT THIS POINT TWO OPTIONS WERE PROVIDED

(A) TO DISCARD ABOUT HALF THE CARDS IN THE DECK TO PRODUCE A SHORT SURVEY, OR

(B) TO RETAIN ALL OF THE CARDS.

MOST RESPONDENTS WANTED TO RETAIN ALL OF THE CARDS. WHEN THE RESULTS OF THIS PART OF THE SURVEY WERE ANALYZED, THE HIGHEST RANKING SERVICE WAS ASSIGNED 10 POINTS; THE NEXT HIGHEST 9 POINTS; ETC. DOWN TO THE 9TH SELECTED SERVICE, WHICH WAS ASSIGNED A SINGLE POINT.


1
2
3
4
5
6
7
31
MISSION SELECTION
1989
1979
1984
1979
SERVICE PROVIDED BY (DATE)
NOT INTER-ESTED
3RD
1ST
NOT INTER-ESTED
2ND
NOT INTER-ESTED
NOT INTER-ESTED
10TH
INTEREST LEVEL
1.2m
4.5m
1.2m
YAGI
EARTH STATION ANTENNA DIAMETER
4 TIME ZONES
CONUS
CLUSTER OF BEAMS
GLOBAL
BEAM COVERAGE
5%
99%
25%
99%
MARKET SHARE (1984)

HAVING DETERMINED THE MOST AND LEAST LIKELY SERVICES IN EACH OF THE THREE TIME FRAMES, WE THEN MOVED ON TO THE TYPICAL EARTH STATION SIZE THAT WOULD BE USED IN EACH OF THE SERVICES. MOST USERS SURVEYED SPOKE OF BOTH PRESENT-DAY AND FUTURE STATION SIZES. RESULTS SHOWN IN THIS REPORT ARE FOR FUTURE STATIONS (AS THESE ARE THE ONES THAT WILL BE IN PLACE IF THE GEOSTATIONARY PLATFORM IS LAUNCHED IN THE 1980's OR 1990's). THE USER WAS GIVEN HIS CHOICE OF SPECIFYING AN EARTH STATION IN TERMS OF ITS ANTENNA DIAMETER (IN FEET OR METERS), OR BY ITS RECEIVING FIGURE OF MERIT (G/T_S). AS SHOWN ON PAGE 8, IF THE TYPE OF SERVICE AND THE FIGURE OF MERIT OF THE RECEIVING STATION ARE KNOWN, THE SATELLITE E.I.R.P. MAY BE DETERMINED. THE E.I.R.P. OF THE SATELLITE CAN THEN BE USED TO FIND THE TRANSMITTER POWER IF THE SATELLITE ANTENNA GAIN IS KNOWN.

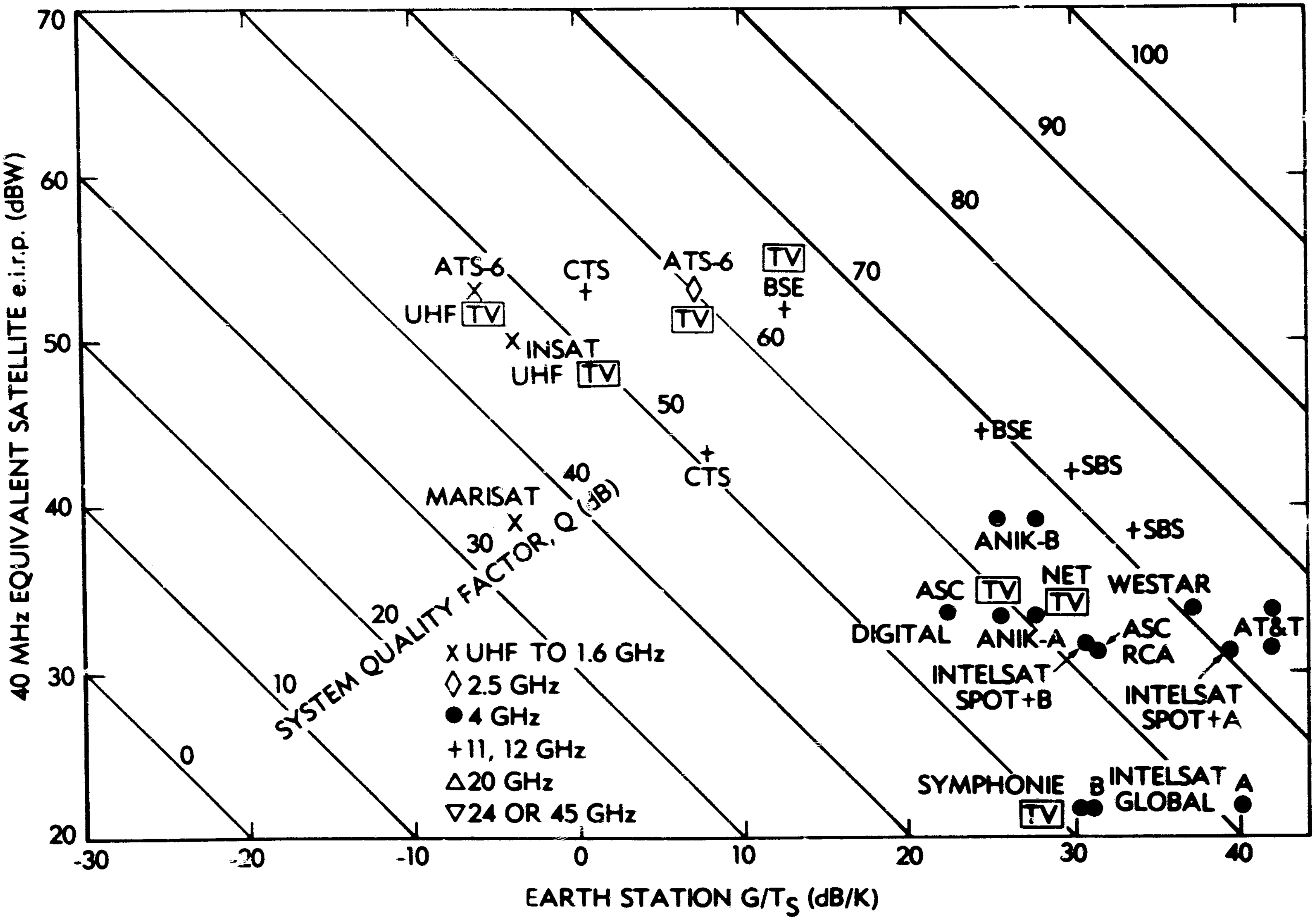
THE SATELLITE ANTENNA GAIN IS DIRECTLY RELATED TO ITS COVERAGE. THE USERS WERE GIVEN A CHOICE OF 8 DIFFERENT TYPES OF COVERAGE (GLOBAL, REGIONAL, CONUS, 4 TIME ZONES, A CLUSTER OF BEAMS, SCANNING OR BAND BEAMS, AND OTHER). AS IN THE CASE OF THE EARTH STATION ANTENNAS, THE USERS WERE ASKED TO SORT THE MISSIONS BY COVERAGE.

HAVING DETERMINED THE TRANSMITTER POWER THROUGH THE USER-SPECIFIED EARTH STATION AND COVERAGE CHOICES, THE NEXT STEP WAS TO DETERMINE HOW MANY TRANSMITTERS (OR TRANSPONDERS) WOULD BE NEEDED.

THE USERS WERE ASKED TO ESTIMATE THE AMOUNT OF THE TOTAL TRAFFIC THAT WOULD GO VIA SATELLITE IN 1984. SIX CARDS REPRESENTING DIFFERENT PERCENTAGES OF THE TOTAL TRAFFIC (1, 5, 10, 25, 50, AND 99%) WERE PROVIDED. THE USERS WERE ASKED TO SORT THE SERVICES AMONG THE SIX PERCENTAGES. AS IN OTHER CARD SELECTIONS SOME USERS OPTED TO STRADDLE BETWEEN PERCENTAGES. IN THESE CASES ONE-HALF OF A POINT WAS ASSIGNED TO EACH OF THE CATEGORIES. BASED ON TODAY'S MARKETPLACE AND THE ESTIMATED MARKETPLACE 5 YEARS HENCE, WE HAVE EXTRAPOLATED AHEAD TO 1989. BY TAKING THIS PERCENTAGE OF THE TOTAL MARKET (ESTIMATED BY OTHERS), IT IS POSSIBLE TO GET AN ESTIMATE OF HOW MUCH TRAFFIC WOULD GO BY SATELLITE IN 1984 AND 1989. FROM THIS CHANNEL CAPACITY ESTIMATE IT IS THEN POSSIBLE (AFTER KNOWING THE NUMBER OF CHANNELS PER TRANSPONDER) TO DETERMINE THE NUMBER OF TRANSPONDERS.

THE FIGURE ON THE ADJACENT PAGE SHOWS THE RESULT OF A PREVIOUS STUDY [1] CONDUCTED BY COMSAT. IT SHOWS THE FIGURE OF QUALITY (Q) AS A FUNCTION OF THE SATELLITE E.I.R.P. AND THE EARTH STATION G/T_S. IT CAN BE SHOWN THAT FOR A GIVEN BANDWIDTH, MODULATION METHOD, AND GRADE OF SERVICE A MISSION TYPE MAY BE SPECIFIED BY Q. THE QUALITY FACTOR (Q) IS DEFINED AS FOLLOWS:

$$Q = \text{E.I.R.P.} + (G/T_S) \qquad \text{(dB)}$$


40 MHz EQUIVALENT SATELLITE e.i.r.p. (dBW)
EARTH STATION G/TS (dB/K)
SYSTEM QUALITY FACTOR, Q (dB)
0
10
20
30
40
50
60
70
80
90
100
ATS-6
UHF TV
CTS
ATS-6
TV
TV
BSE
INSAT
UHF TV
MARISAT
CTS
+BSE
+SBS
+SBS
ANIK-B
ASC
TV
NET
TV
WESTAR
DIGITAL
ANIK-A
ASC
RCA
AT&T
INTELSAT
SPOT+B
INTELSAT
SPOT+A
SYMPHONIE
TV
B
INTELSAT
GLOBAL
A
X UHF TO 1.6 GHz
◊ 2.5 GHz
● 4 GHz
+ 11, 12 GHz
Δ 20 GHz
∇ 24 OR 45 GHz

SURVEY CONDUCT

A LONG LIST OF POTENTIAL CONTACTS WAS PREPARED. LISTS WERE ALSO COMPILED OF THE 31 POTENTIAL MISSIONS AND THE SKILLS INVOLVED IN SATELLITE SYSTEM OPERATION AND USE.

MATRICES WERE PREPARED AND USED TO IDENTIFY ORGANIZATIONS WITH EITHER BROAD INTERESTS OR A SPECIALTY TO HELP BALANCE THE SURVEY. INDIVIDUALS WERE THEN SELECTED. NEARLY 30 PERSONS PARTICIPATED IN THE SURVEY.

EACH PARTICIPANT SELECTED WAS A SENIOR MAN WITH EXTENSIVE RESPONSIBILITIES AND A PROFESSIONAL REPUTATION FOR LONG-RANGE PLANNING.

THE ORIGINAL INTENT WAS TO LIMIT EACH SURVEY TO 45 MINUTES, BUT IT SOON BECAME EVIDENT THAT THE PARTICIPANTS FELT THE SURVEY WAS MUTUALLY BENEFICIAL AND IMPORTANT. THE PROCEDURE WAS STRUCTURED TO ALLOW EITHER A BRIEF OR EXTENDED SESSION AND COULD BE ADMINISTERED ON EITHER A ONE TO ONE OR COMMITTEE BASIS.

SURVEY CONTACTS

ORGANIZATION	LEVEL
Aerospace Corporation	(Fred Bond)
American Satellite Corporation	Vice President
American Telephone & Telegraph	Vice President
Dow Jones & Co.	Vice President & Staff
International Telecommunications Satellite Organization	Director General's Staff
RCA-AE	Vice President's Staff
RCA American Communications Corp.	Vice President & Staff
Satellite Business Systems	Vice President & Staff
Scientific Atlanta	President & Staff
Southern Satellite Systems	Vice President
Turner Communications Corporation	Vice President
Western Union Telegraph Co.	Vice Presidents

CONTROL QUESTIONS

WHEN THE SURVEY WAS CONSTRUCTED A NUMBER OF CONTROL QUESTIONS WERE BUILT IN FOR VERIFICATION PURPOSES.

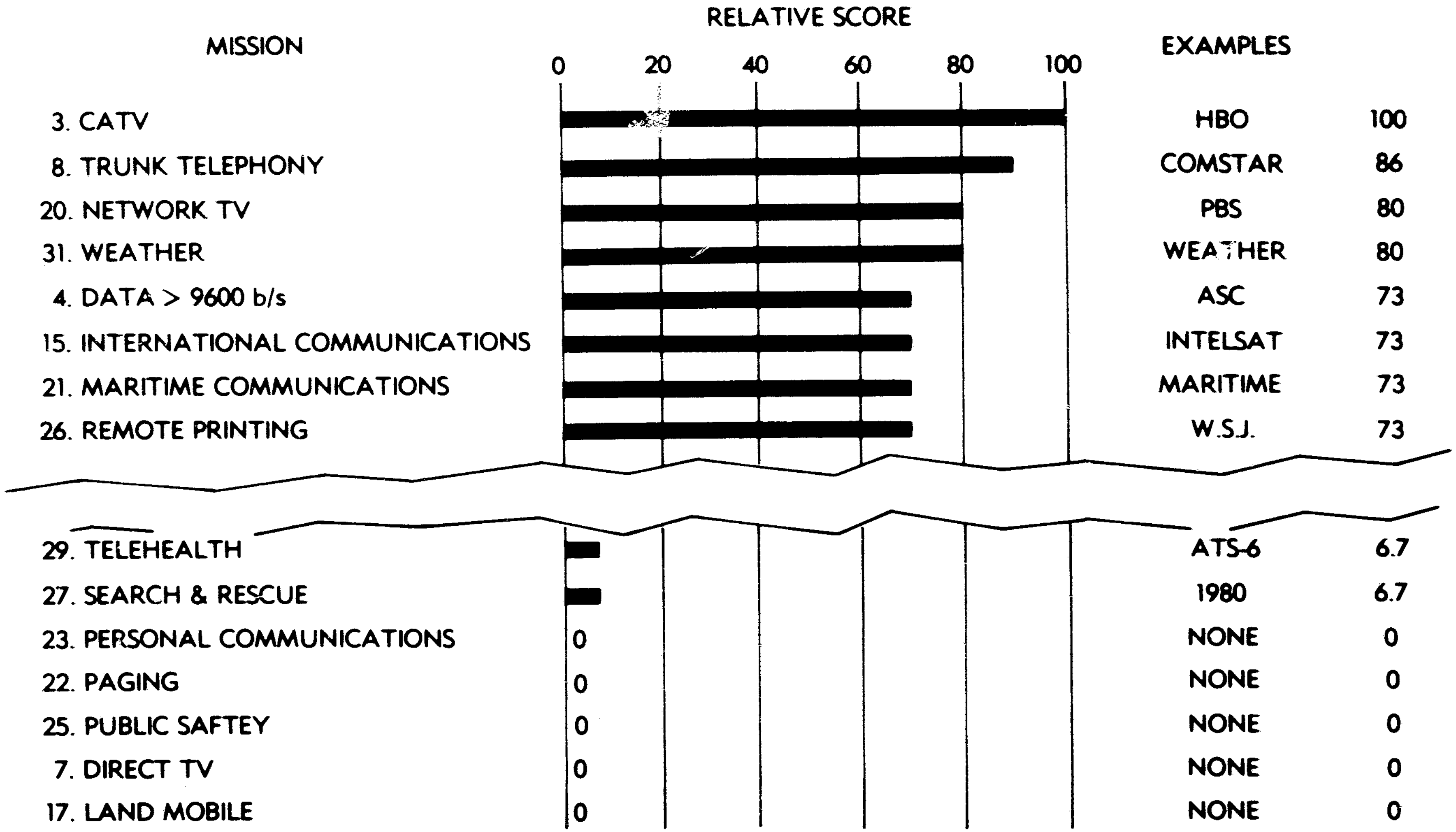
THIS CHART SHOWS THE RESULTS OF ASKING USERS TO SORT THE MISSION CARDS INTO FOUR PILES: PRESENTLY IN SERVICE, 1984, 1989, LATER OR UNKNOWN DATE.

THE MISSION CARDS ARE LISTED DOWN THE LEFT COLUMN. ON THE RIGHT SIDE IS A LIST OF PRESENT DAY SATELLITES OR SERVICE USERS.

BOTH ENDS OF THE SCALE ARE SHOWN. ALL OF TODAY'S MAJOR SERVICES WERE PROPERLY IDENTIFIED. SYSTEMS THAT HAVE RECEIVED ONLY BRIEF EXPERIMENTAL TESTS WERE RANKED LOW.

OTHER KEY CONTROL QUESTIONS MAY BE NOTICED IN THE DATA WHICH FOLLOW.

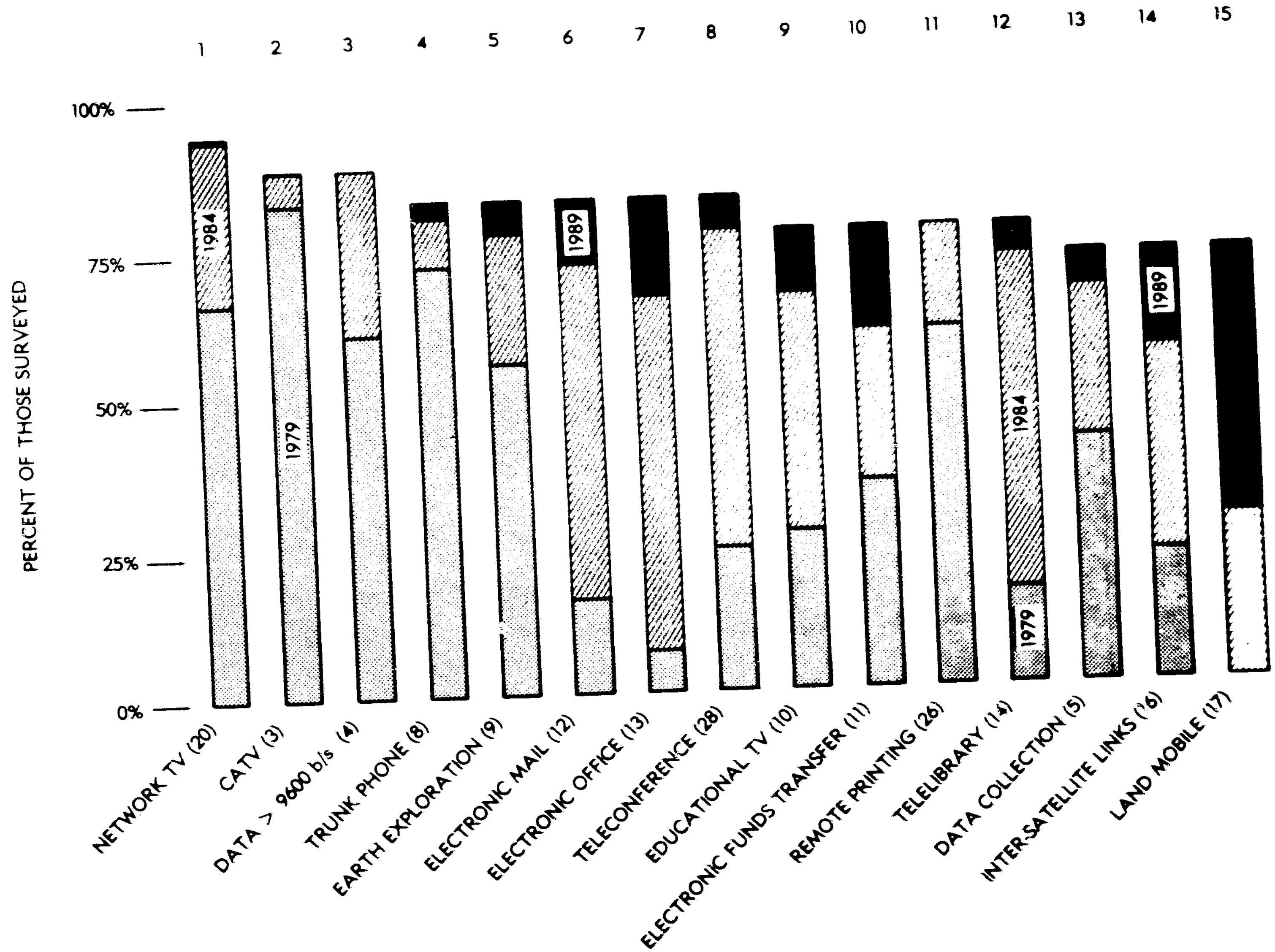
CONTROL QUESTION: IDENTIFY 1979's SERVICES

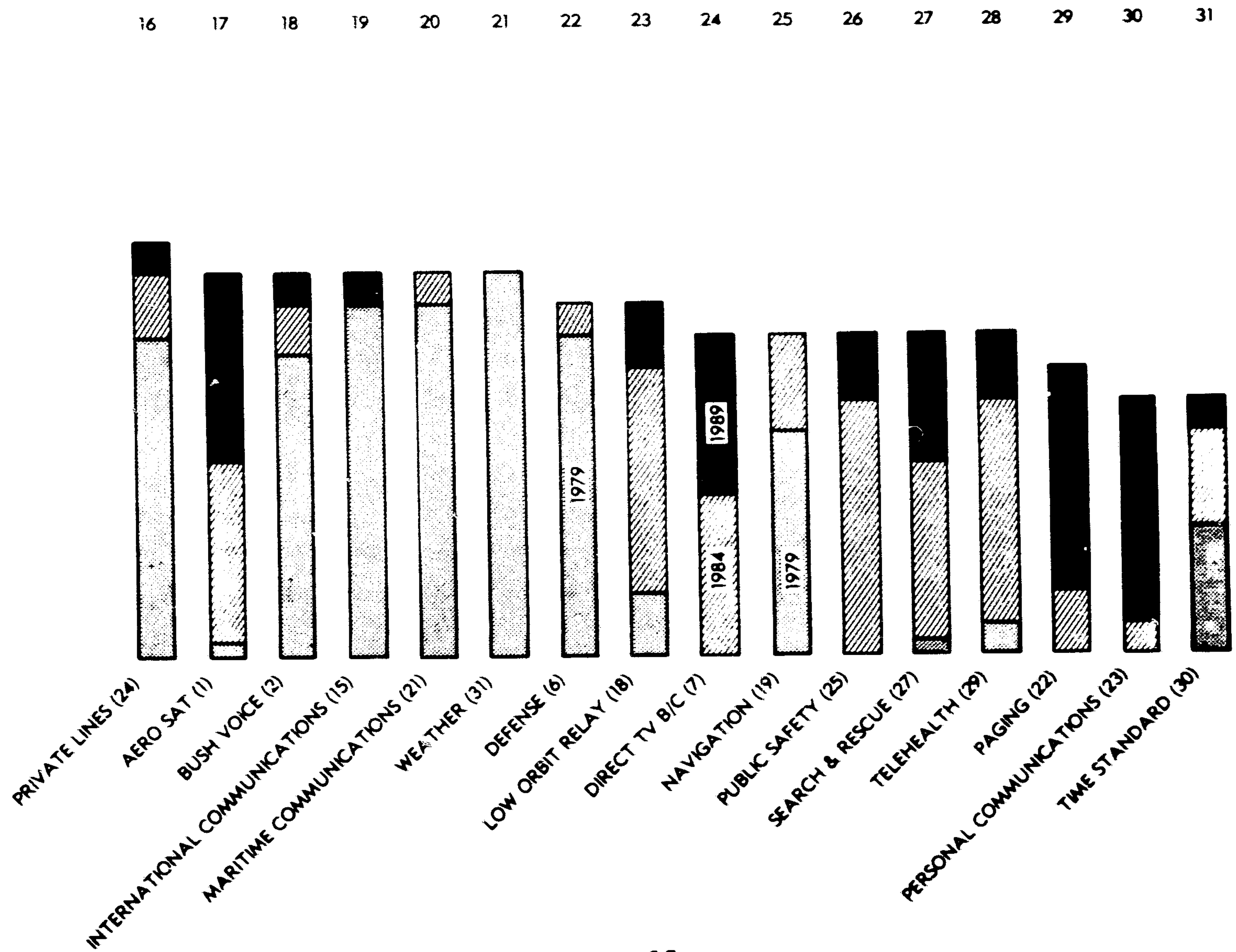


APPROXIMATE DATE OF SUBSTANTIAL SERVICE INTRODUCTION

THE FOLLOWING TWO PAGES SHOW A WEIGHTED AVERAGE OF THE RESPONSES. THE WEIGHTING WAS DONE ON THE BASIS OF THE PROXIMITY OF THE PERSON BEING SURVEYED TO EACH OF THE 31 POTENTIAL MISSIONS.

RESPONSE BY DATE OF SUBSTANTIAL SERVICE AVAILABILITY




16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
1979
1989
1984
1979
PRIVATE LINES (24)
AERO SAT (1)
BUSH VOICE (2)
INTERNATIONAL COMMUNICATIONS (15)
MARITIME COMMUNICATIONS (21)
WEATHER (31)
DEFENSE (6)
LOW ORBIT RELAY (18)
DIRECT TV B/C (7)
NAVIGATION (19)
PUBLIC SAFETY (25)
SEARCH & RESCUE (27)
TELEHEALTH (29)
PAGING (22)
PERSONAL COMMUNICATIONS (23)
TIME STANDARD (30)

APPROXIMATE DATE OF SUBSTANTIAL SERVICE INTRODUCTION

1.	Aeronautical Communications	1985
2.	Bush Voice	(now)
3.	CATV	(now)
4.	Data (> 9600 b/s)	some now, bulk by 1981
5.	Data Collection	little now, 1984
6.	Defense	(now)
7.	Direct TV Broadcast (USA)	1987
8.	Trunk Telephone	(now)
9.	Earth Exploration	(now)
10.	Educational TV - PBS	(now)
	- Dedicated Transponder	1980
	- Dedicated Satellite	1985 (?)
11.	Electronic Funds Transfer	little now, 1985
12.	Electronic Mail (USA)	(depends on Congress)
13.	Electronic Office	1982
14.	Telelibrary	little now, 1984
15.	International	(now)
16.	Inter Satellite Links	LES-8-9 now, commercial service: 1988

APPROXIMATE DATE OF SUBSTANTIAL SERVICE INTRODUCTION (CONT.)

17.	LAND MOBILE	1990
18.	LOW ORBIT RELAY	1981
19.	NAVIGATION	LOW ORBIT NOW, SYNC: 1985
20.	NETWORK TV	PBS NOW, OTHERS: 1980
21.	MARITIME	(NOW)
22.	PAGING (FROM ORBIT)	1990+
23.	PERSONAL COMMUNICATION - COMMERCIALLY SPONSORED	1995+
	- NASA SPONSORED	1987
24.	PRIVATE LINES	(NOW)
25.	PUBLIC SAFETY	1987
26.	REMOTE PRINTING	(NOW)
27.	SEARCH & RESCUE	1983
28.	TELECONFERENCE	1982
29.	TELEHEALTH	1982
30.	TIME & FREQUENCY STANDARDS	1983
31.	WEATHER	(NOW)

MISSION CONSOLIDATION

AS INDICATED ON PAGE 2, TASK 1.2A INVOLVES THE SELECTION OF MISSIONS BASED ON THE USER SURVEY. THE FACING PAGE SHOWS THE CONSOLIDATION OF RELATED MISSIONS. FOR INSTANCE TRUNK TELEPHONE (NUMBER 8) AND PRIVATE LINE TELEPHONE (NUMBER 24) WERE CITED BY SEVERAL USERS AS BEING SIMILAR. THESE ARE NOW CONSOLIDATED INTO MISSION "A. VOICE". THREE CASES OF VIDEO WERE DEVELOPED. MISSION "F. DATA" COMBINES FIVE MISSIONS THAT HAVE COMMON TRAFFIC SOURCES AND SINKS ALTHOUGH THE DATA RATES AND TIMELINESS OF THE COMMUNICATIONS DIFFER SLIGHTLY.

MISSION CONSOLIDATION

PRIOR MISSION NUMBER & DESIGNATION	CHANNEL BANDWIDTH	TERRESTRIAL DISTRIBUTION	NEW MISSION DESIGNATION
8. TRUNK TELEPHONY	3-4 kHz	EXISTS	
24. PRIVATE LINES	3-4 kHz	EXISTS	A. VOICE
3. CATV	19-25 MHz	CABLE	
20. NETWORK TV	19-25 MHz	LOCAL TV STATIONS	B. VIDEO
10. EDUCATIONAL TV	19-25 MHz	DIRECT, CABLE, ITFS OR TV STATION	C. VIDEO
7. DIRECT TV BROADCAST	19-25 MHz	DIRECT FROM SPACE	D. VIDEO
4. DATA>9.6 KB/S	(DIGITAL)	EXISTS	
11. ELECTRONIC FUNDS TRANSFER	(DIGITAL)	EXISTS	E. DATA
12. ELECTRONIC MAIL (FAX)	(DIGITAL)	DIRECT	
13. ELECTRONIC OFFICE	(DIGITAL)	DIRECT	
14. TELELIBRARY	(DIGITAL)	DIRECT	F. DATA
26. REMOTE PRINTING	(DIGITAL)	DIRECT	
28. TELECONFERENCE	(DIGITAL)	DIRECT	
1. AERONAUTICAL	3 kHz	EXISTS	
19. NAVIGATION (AIR)	LOW	EXISTS	G. MOBILE AIR

MISSION CONSOLIDATION (CONT.)

PRIOR MISSION NUMBER & DESIGNATION	CHANNEL BANDWIDTH	TERRESTRIAL DISTRIBUTION	NEW MISSION DESIGNATION
19. NAVIGATION (SEA)	LOW	EXISTS	
21. MARITIME	3 kHz	DIRECT	H. MOBILE, SEA
27. SEARCH & RESCUE (SEA)	LOW	DIRECT	
2. BUSH VOICE	3 kHz	DIRECT	
17. LAND MOBILE	3 kHz	DIRECT	I. MOBILE, LAND
19. NAVIGATION (LAND)	LOW	DIRECT	
15. INTERNATIONAL	4 kHz	EXISTS	J. INTERNATIONAL
16. INTER-SAT. LINKS	VARIES	N.A.	K. INTER-SATELLITE
31. WEATHER	VARIES	EXISTS	L. WEATHER
5. DATA COLLECTION	VARIES	EXISTS	M. DATA COLLECTION
25. PUBLIC SAFETY	VARIES	DIRECT	N. PUBLIC SERVICES
29. TELEHEALTH	VARIES	DIRECT	
18. TDRSS	-	-	—TDRS
6. DEFENSE	-	-	
9. EARTH EXPLORATION	-	-	ELIMINATED
22. PAGING	-	-	
23. PERSONAL COMMUNICATIONS	-	-	
30. TIME & FREQUENCY	-	-	

PRELIMINARY MISSION DETAILS

THESE CHARTS SHOW THE DETAILS OF EACH OF THE MISSIONS. CERTAIN CONSTRAINTS HAVE BEEN IMPOSED TO MAKE THESE MISSIONS COMPATIBLE WITH PRIOR NASA STUDIES: IN PARTICULAR, 40 MHz IS CONTINUED AS THE BASIC BANDWIDTH FOR MOST SERVICES AND THE BAND SELECTIONS ARE SIMILAR.

KEY

FDMA - FREQUENCY DOMAIN MULTIPLE ACCESS
MCPT - MULTI-CARRIER PER TRANSPONDER
TDMA - TIME DOMAIN MULTIPLE ACCESS
SCPC - SINGLE CHANNEL PER CARRIER
SCPT - SINGLE CARRIER PER TRANSPONDER

DESIGNATION		FREQUENCY (GHz)	EARTH STN G/Ts (dBi/K)	BANDWIDTH PER XPDR (MHz)	XPDR e.i.r.p. (dBW)
PRIOR	NEW				
VOICE SERVICES (MCPT/FDMA)†					
8. TRUNK TELEPHONE†	A. VOICE	6/4	30	500	50.4*
24. PRIVATE LINES†	A. VOICE	6/4	20	40	40*
VIDEO SERVICES (SCPT)†					
3. CATV†	B. VIDEO	14/13	25	40	46**
20. NETWORK TV†	B. VIDEO	14/13	25	40	TBD**
10. EDUCATIONAL TV	C. VIDEO	14/2.5	15	20	35.9
7. DIRECT TV BROADCAST	D. VIDEO	14/UHF	-7	40	51.3

*BASED ON AEROSPACE CORPORATION'S "HIGH VOLUME TRUNKING" MODEL BUT MODIFIED FOR 30 dBi/K EARTH STATION INSTEAD OF 26 dBi/K. A. VOICE INCLUDES AN ALLOWANCE OF 4 dB FOR OFF-AXIS ANTENNA COVERAGE. AN 8 dB BACKOFF HAS BEEN INCLUDED FOR MCPT.

**BASED ON AEROSPACE CORPORATION'S "BROADCAST AND VIDEO DISTRIBUTION" MODEL BUT MODIFIED FOR 25 dBi/K (INSTEAD OF 28.5 dBi/K) EARTH STATIONS.

†SUBSEQUENT NASA DIRECTION REPLACED THESE MODELS WITH THOSE DEVELOPED UNDER THE AEROSPACE CORPORATION CONTRACT.

DESIGNATION		FREQUENCY (GHz)	EARTH STN G/Ts (dBi/K)	BANDWIDTH PER XPDR (MHz)	XPDR e.i.r.p. (dBW)
PRIOR	NEW				
DATA SERVICES (SCPT/TDMA)					
4. DATA >9.6 kbit/s†	E. DATA	14/12	20	40	55*
11. ELECTRONIC FUNDS TRANSFER†	E. DATA	14/12	20	40	55*
12. ELECTRONIC MAIL†	F. DATA	14/12	22	50	TBD
13. ELECTRONIC OFFICE†	F. DATA	14/12	22	50	TBD
14. TELELIBRARY†	F. DATA	14/12	22	50	TBD
28. TELECONFERENCING†	F. DATA	14/12	22	50	TBD
26. REMOTE PRINTING†	F. DATA	14/12	22	50	TBD

*BASED ON AEROSPACE CORPORATION'S "DIRECT TO USER" MODEL BUT MODIFIED FOR A 20 dBi/K STATION (INSTEAD OF 28 dBi/K).

†SUBSEQUENT NASA DIRECTION REPLACED THESE MODELS WITH THOSE DEVELOPED UNDER THE AEROSPACE CORPORATION CONTRACT.

DESIGNATION		FREQUENCY (GHz)	EARTH STN G/Ts (dBi/K)	BANDWIDTH PER XPDR (MHz)	XPDR e.i.r.p. (dBW)
PRIOR	NEW				
MOBILE SERVICES (MCPT)					
1. AERONAUTICAL	G. MOBILE, AIR	1.6/1.5	-7.4	80 KHZ	33.0
21. MARITIME	H. MOBILE, SEA	1.6/1.5	-4	200 KHZ	29.5
19 NAVIGATION (SEE AERO., LAND OR MARITIME)					
22. SEARCH & RESCUE (SEE AERO., LAND OR MARITIME)					
17. LAND MOBILE	I. MOBILE, LAND	0.9/0.9	-15.5	17	65.2
2. BUSH VOICE	I. MOBILE, LAND	0.9/0.9	-15.5	2	56.2

DESIGNATION		FREQUENCY (GHz)	EARTH STN G/Ts (dBi/K)	BANDWIDTH PER XPDR (MHz)	XPDR e.i.r.p. (dBW)
PRIOR	NEW				
INTERNATIONAL SERVICES (MCPT/FDMA)					
1[illegible]. INTERNATIONAL	J. INTERNATIONAL	6/4	40	40	16.2
		14/11	30	80	44.0
		30/20	30	100	59.5
16. INTER-PLATFORM LINK	K. INTERSATELLITE LINK	55/55	30	500	75.5
METEOROLOGICAL SERVICES (SCPT)					
31. WEATHER	L. WEATHER	14/17	30	6	43.3
		14/0.137	0	50 KHZ	-3.4

DESIGNATION		FREQUENCY (GHz)	EARTH STN G/Ts (dBi/K)	BANDWIDTH PER XPDR (MHz)	XPDR e.i.r.p. (dBW)
PRIOR	NEW				
PUBLIC & SENSORY SERVICES (MCPT)					
5. DATA COLLECTION	M. DATA COLLECTION	0.4/0.4	-17.2	30 KHZ	19.7
25. PUBLIC SAFETY*	N. PUBLIC	8/7	20	20	41.8
29. TELEHEALTH*	N. PUBLIC	8/7	20	20	41.8

*SUBSEQUENT NASA DIRECTION REPLACED THESE MODELS WITH THOSE DEVELOPED UNDER THE AEROSPACE CORPORATION CONTRACT.

EARTH STATION SURVEY

EARTH STATION SURVEY

THESE ARE THE RESULTS OF REDUCING THE EARTH STATION DATA.

IN SOME CASES (FOR INSTANCE INTERNATIONAL COMMUNICATIONS) MORE THAN ONE CLASS OF STATION IS EVIDENT (IN THIS CASE THE INTELSAT STANDARDS A, B, AND C).

SOME SERVICES (PARTICULARLY WEATHER) MAY USE TWO TYPES OF STATIONS: MAJOR READOUT STATIONS WITH A HIGH G/T_S (LIKE WALLOPS ISLAND, VA) AND VERY SIMPLE STATIONS FOR DIRECT PICTURES FROM THE LOW DATA RATE SCANNING RADIOMETERS OR VIDECON CAMERAS (FOR EXAMPLE APT).

THE USER WAS GIVEN A CHOICE OF POTENTIAL EARTH STATION SIZES (EXPRESSED IN TERMS OF ANTENNA DIAMETER AND ITS FIGURE OF MERIT). HE WAS ASKED TO SELECT THE PREFERRED STATION SIZE FOR THE 1980's.

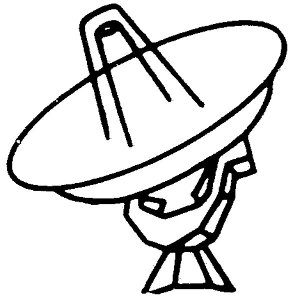
THE SELECTIONS ESTABLISHED THE RECEIVING STATION PERFORMANCE: $(G/T_S)_D$.

THE DOWN-LINK FIGURE OF QUALITY (Q_D) IS CONSTANT FOR A GIVEN BANDWIDTH, SIGNAL-TO-NOISE RATIO (TRAFFIC PERFORMANCE) AND MODULATION METHOD:

$$Q_D = (\text{E.I.R.P.})_D + (G/T_S)_D$$

THUS FOR A GIVEN Q_D THE E.I.R.P. OF THE SATELLITE MAY BE ESTABLISHED.

CODE	ANT.	DIA.	G/Ts	MISSION	ALTERNATE
A40	30m	100'	40	15. INT'L COMMUNICATIONS	A30
A30	10m	32'	30	8. TRUNK TELEPHONE	
				9. EARTH EXPLORATION	
				15. INT'L COMMUNICATIONS	A40
				18. LOW ORBIT RELAY (EARTH STATION)	
				20. NETWORK TV	A25
				26. REMOTE PRINTING	A25
				31. WEATHER (MAJOR READOUT STATION)	
				24. PRIVATE LINES	A20
A25	4.5m	15'	25	3. CATV	A20
				4. DATA 9.6 kbit/s	A20
				12. ELECTRONIC MAIL	A20
				13. ELECTRONIC OFFICE	A20
				20. NETWORK TV	A30
				26. REMOTE PRINTING	A30
				28. TELECONFERENCING	



CODE	ANT.	DIA.	G/Ts	MISSION	ALTERNATE
A20	3m	10'	20	3. CATV	A25
				4. DATA 9.6 kbit/s	A25
				10. EDUCATIONAL TV	
				11. ELECTRONIC FUNDS TRANSFER	
				12. ELECTRONIC MAIL	A25
				13. ELECTRONIC OFFICE	A25
				14. TELELIBRARY	
				24. PRIVATE LINES	A30
				25. PUBLIC SAFETY	
				29. TELEHEALTH	A10
A10	1.2m	4'	10	2. BUSH VOICE	
				5. DATA COLLECTION	
				7. DIRECT TV BROADCAST	AW
				21. MARITIME	
				29. TELEHEALTH	A20
				30. TIME STANDARD	

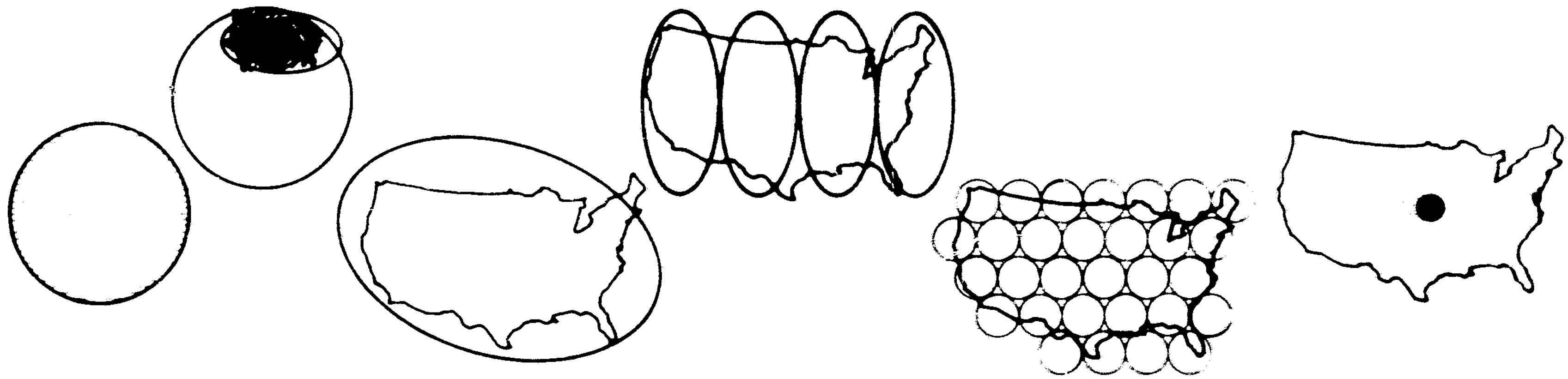
CODE	ANT.	DIA.	G/Ts	MISSION	ALTERNATE
AW	WIRE-TYPE ANTENNA			1. AERONAUTICAL	A0
				7. DIRECT TV BROADCAST	A10
				17. LAND MOBILE	A0
				19. NAVIGATION	
				23. PERSONAL COMM.	A0
				27. SEARCH & RESCUE	
				31. WEATHER (SIMPLE READOUT)	
A0	OMNIDIRECTIONAL			1. AERONAUTICAL	AW
				17. LAND MOBILE	AW
				22. PAYING	
				23. PERSONAL COMM.	AW
				6. DEFENSE	(MANY)
				16. INTERSATELLITE	(N.A.)

SATELLITE ANTENNAS

SATELLITE ANTENNAS

KNOWING A SATELLITE E.I.R.P. IS USEFUL BUT UNLESS THE TRANSMIT ANTENNA GAIN IS KNOWN THERE IS NO WAY TO ESTIMATE THE POWER AMPLIFIER SIZE.

THE SATELLITE ANTENNA GAIN IS DETERMINED BY THE DOWN-LINK BEAM COVERAGE.



SATELLITE BEAMS

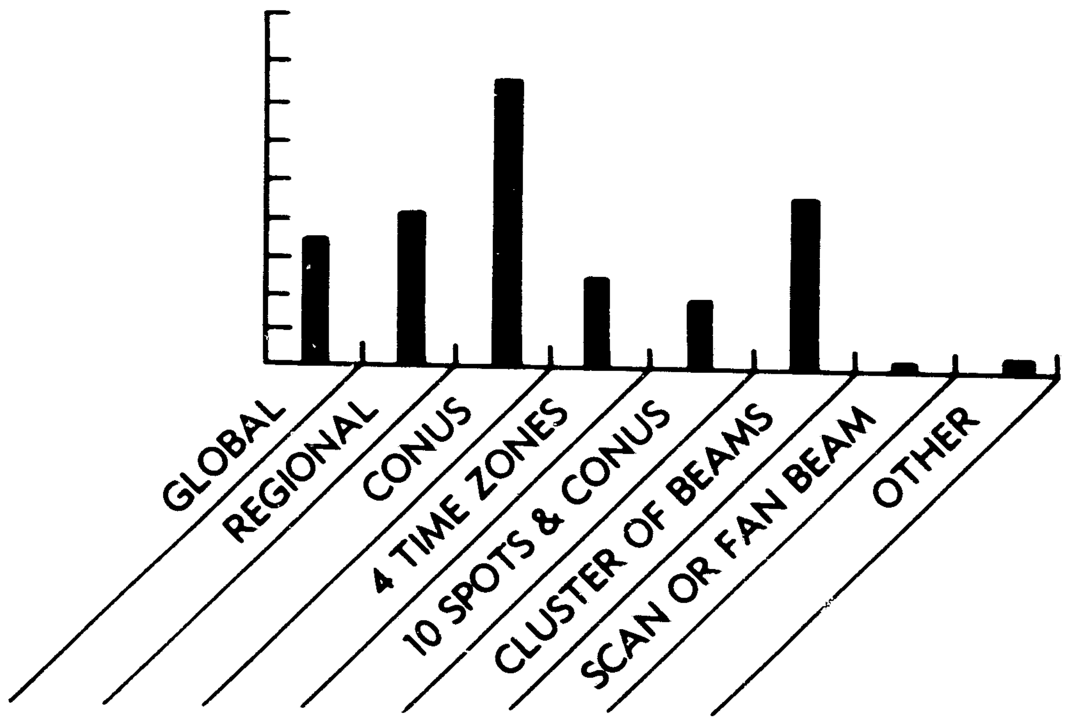
THE USERS WERE ASKED TO SORT THE SELECTED MISSION AMONG EIGHT COVERAGE PATTERNS. MANY TENDED TO SELECT WHAT WAS CURRENTLY BEING USED (SUCH AS GLOBAL OR CONUS). A SUBSTANTIAL NUMBER SELECTED THE CLUSTER OF BEAMS OR THE 10 BEAM CHOICES.

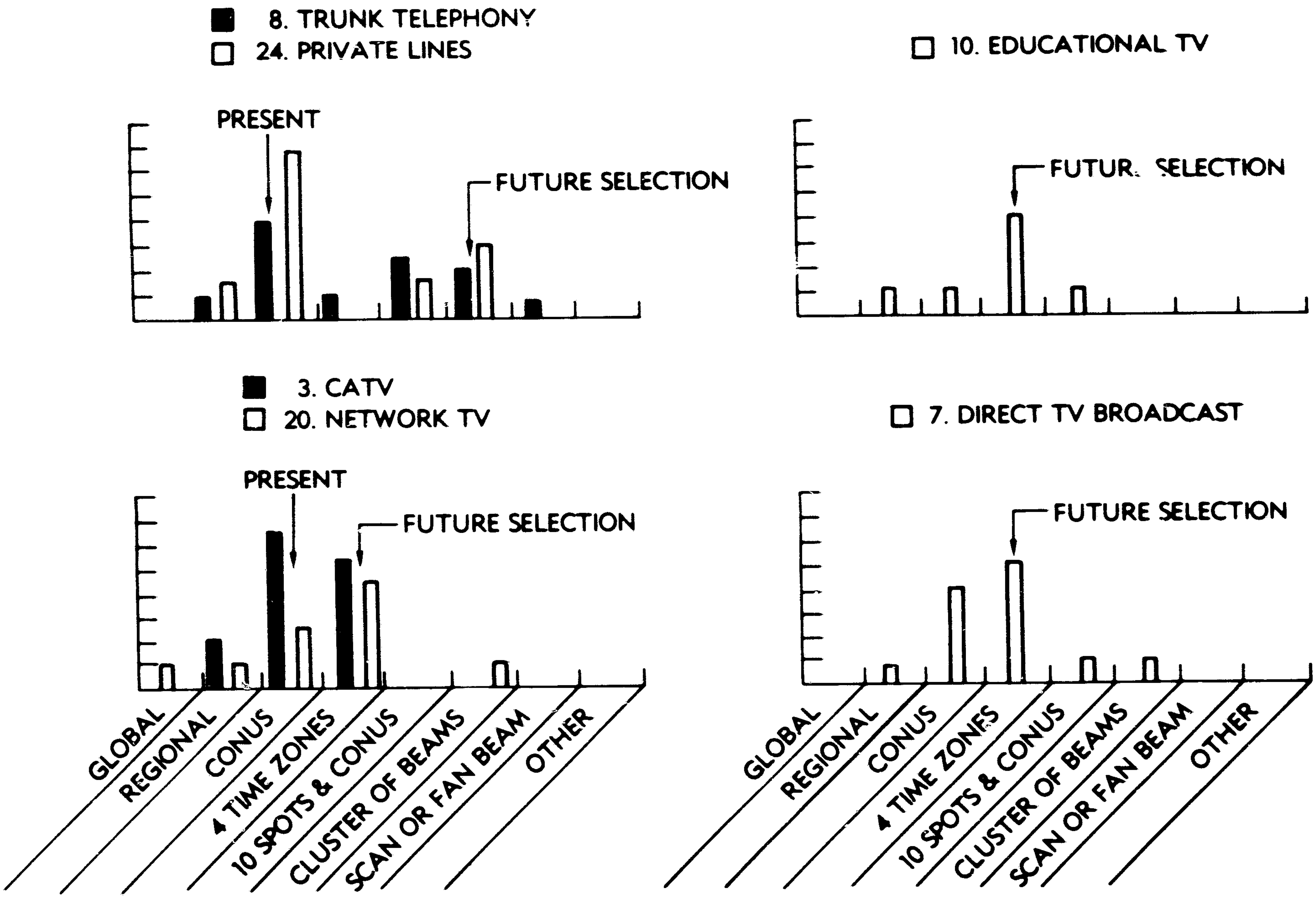
LATER I INFORMALLY ASKED SOME PEOPLE WHAT A USER WOULD DO IF THERE WAS INSIGNIFICANT SPECTRUM AVAILABLE. THE USUAL ANSWER WAS TO GO TO MORE BEAMS TO OBTAIN FREQUENCY REUSE.

THE FIRST GRAPH SHOWS THE OVERALL SELECTION (FOR ALL MISSIONS).

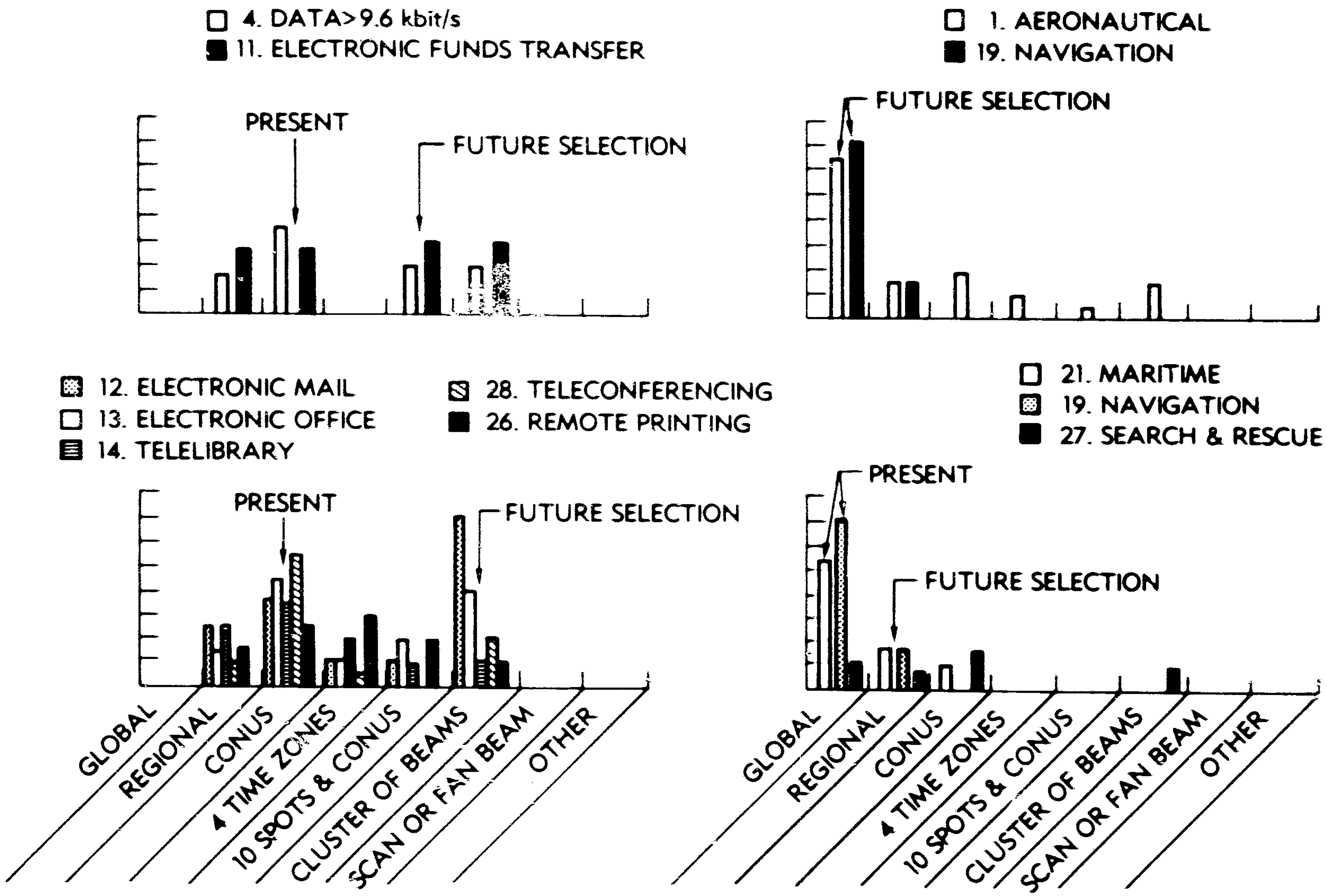
SUBSEQUENT GRAPHS ARE PROVIDED ON A MISSION BY MISSION BASIS. BOTH THE PRESENT AND FUTURE SELECTIONS ARE SHOWN.

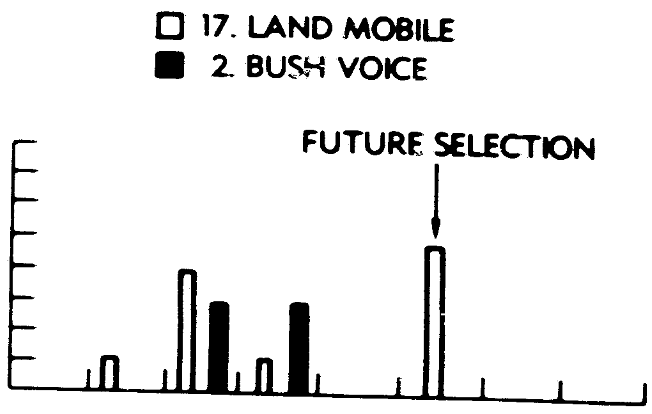
OVERALL

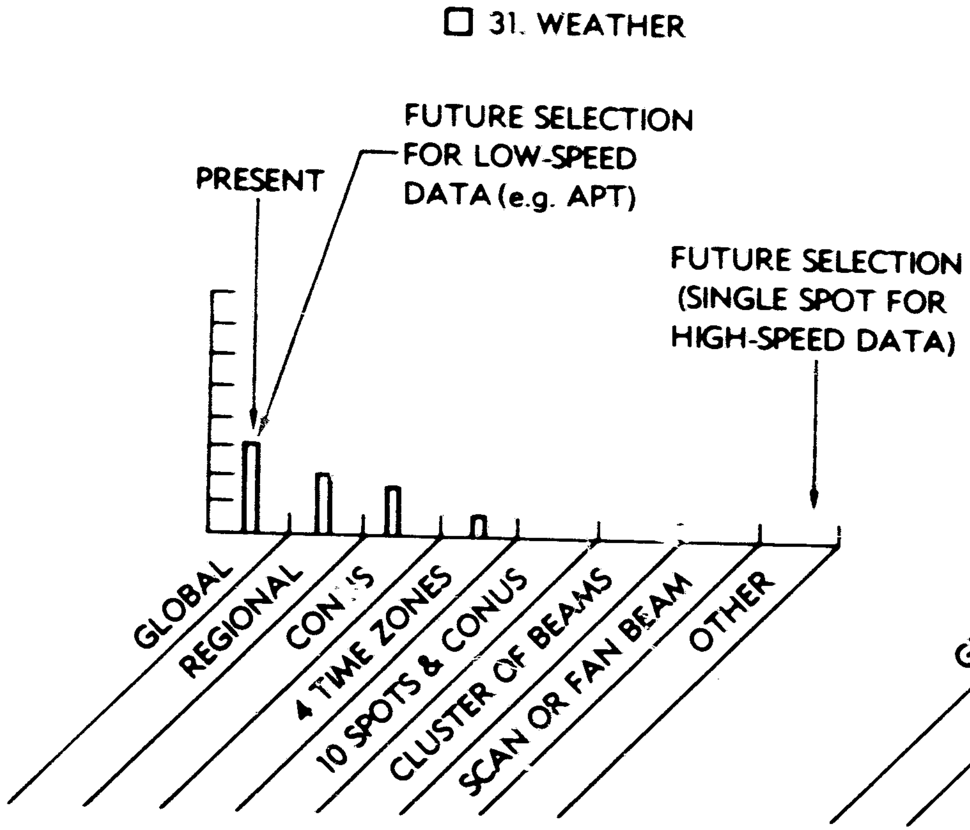

GLOBAL
REGIONAL
CONUS
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER

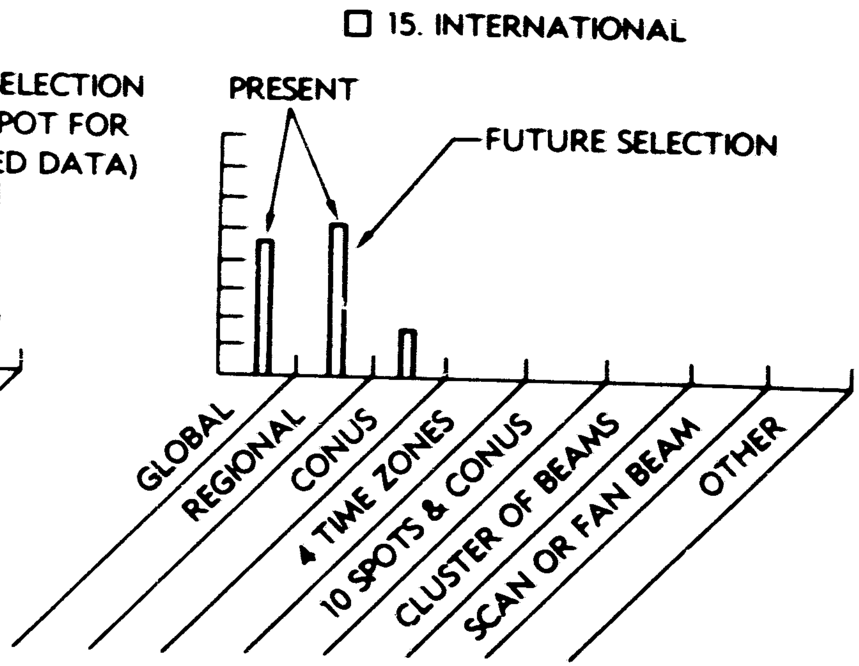


8. TRUNK TELEPHONY
24. PRIVATE LINES
PRESENT
FUTURE SELECTION
10. EDUCATIONAL TV
FUTUR. SELECTION
3. CATV
20. NETWORK TV
PRESENT
FUTURE SELECTION
7. DIRECT TV BROADCAST
FUTURE SELECTION
GLOBAL
REGIONAL
CONUS
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER

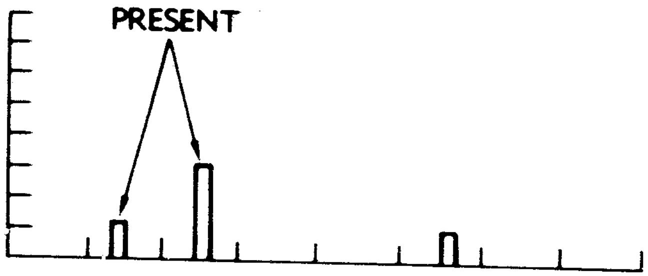

4. DATA>9.6 kbit/s
11. ELECTRONIC FUNDS TRANSFER
PRESENT
FUTURE SELECTION
1. AERONAUTICAL
19. NAVIGATION
FUTURE SELECTION
12. ELECTRONIC MAIL
13. ELECTRONIC OFFICE
14. TELELIBRARY
28. TELECONFERENCING
26. REMOTE PRINTING
PRESENT
FUTURE SELECTION
21. MARITIME
19. NAVIGATION
27. SEARCH & RESCUE
PRESENT
FUTURE SELECTION
GLOBAL
REGIONAL
CONUS
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER
GLOBAL
REGIONAL
CONUS
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER


17. LAND MOBILE
2. BUSH VOICE
FUTURE SELECTION

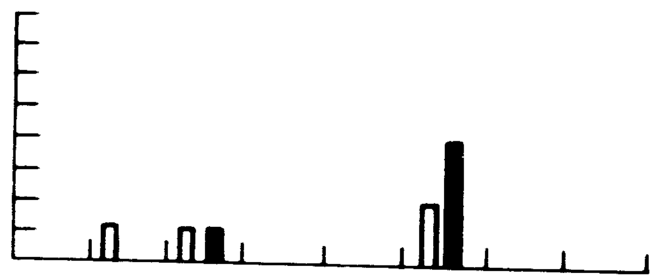

31. WEATHER
PRESENT
FUTURE SELECTION FOR LOW-SPEED DATA (e.g. APT)
FUTURE SELECTION (SINGLE SPOT FOR HIGH-SPEED DATA)
GLOBAL
REGIONAL
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER


15. INTERNATIONAL
PRESENT
FUTURE SELECTION
GLOBAL
REGIONAL
CONUS
4 TIME ZONES
10 SPOTS & CONUS
CLUSTER OF BEAMS
SCAN OR FAN BEAM
OTHER

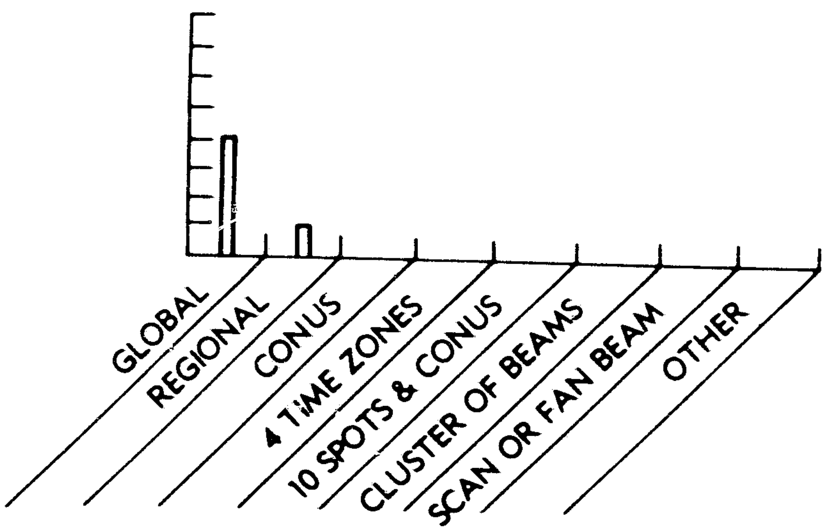
5. DATA COLLECTION



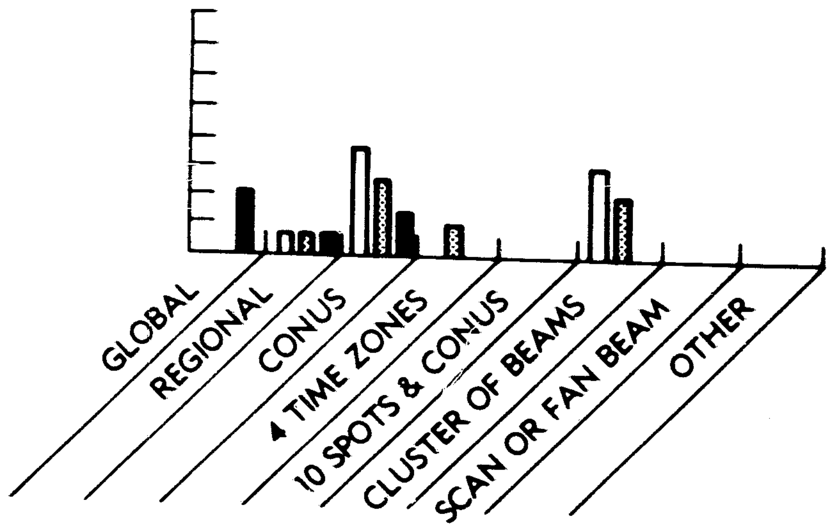
22. PAGING
23. PERSONAL COMM



9. EARTH EXPLORATION



25. PUBLIC SAFETY
29. TELEHEALTH
30. TIME/FREQUENCY STANDARD



BEAMS

- EVENTUAL NEED FOR MULTIBEAM CONFIGURATION.
- FAN BEAM WILL BE USED ON NEXT COMSTAR FAMILY.
- MORE COMPLEX BEAMS WILL BE USED ONLY WHEN NEEDED.
- WILL USE MORE AND MORE COMPLEX BEAMS TO GET FREQUENCY REUSE.

MARKET INFORMATION

MARKET INFORMATION

THE USERS WERE ASKED TO RANK THE MISSIONS THEY HAD SELECTED AS BEING SIGNIFICANTLY IMPLEMENTED BY 1979, 1984, OR 1989.

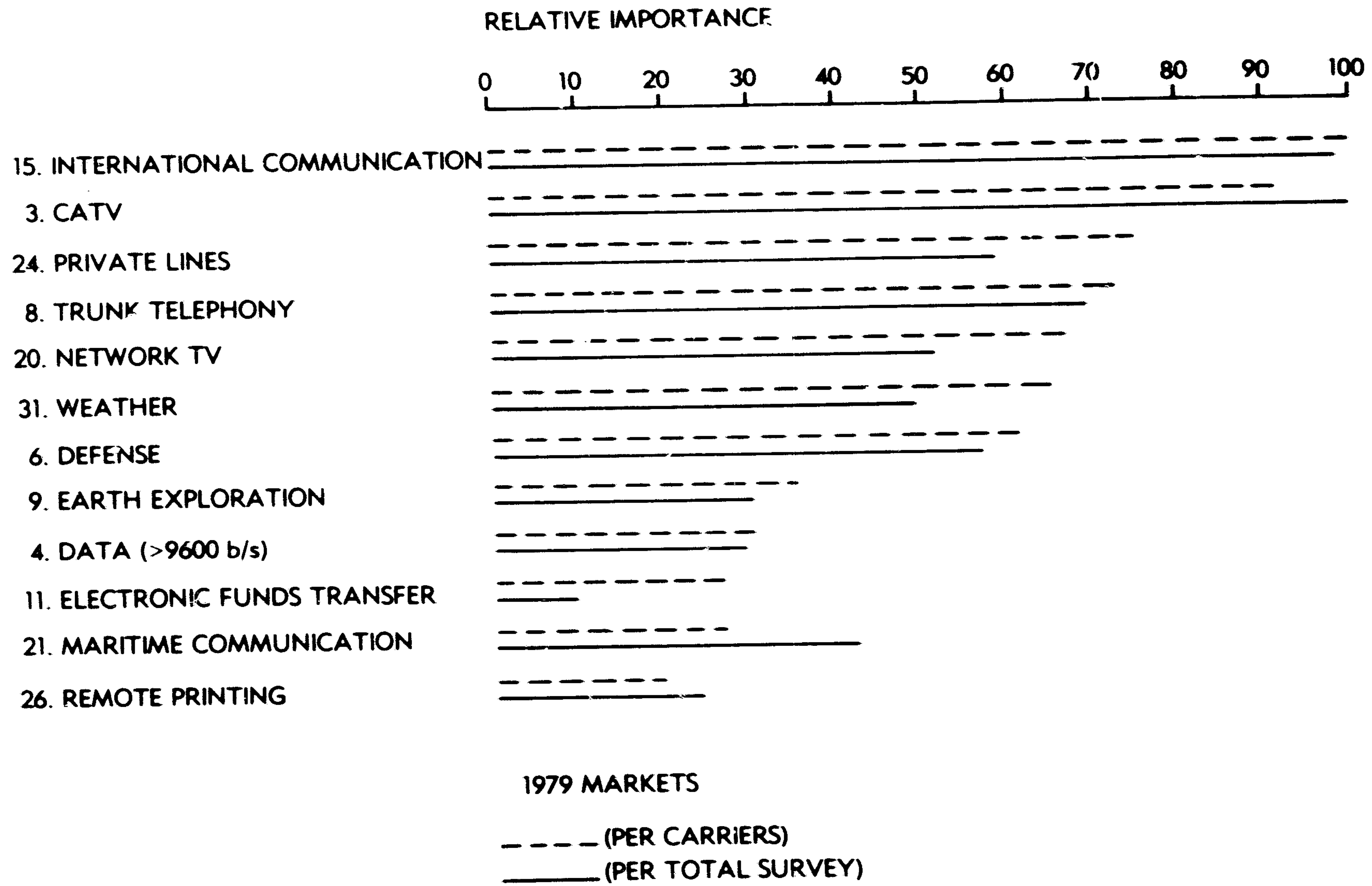
THE FIRST CHOICE WAS AWARDED 10 POINTS, THE SECOND 9 POINTS, ETC.

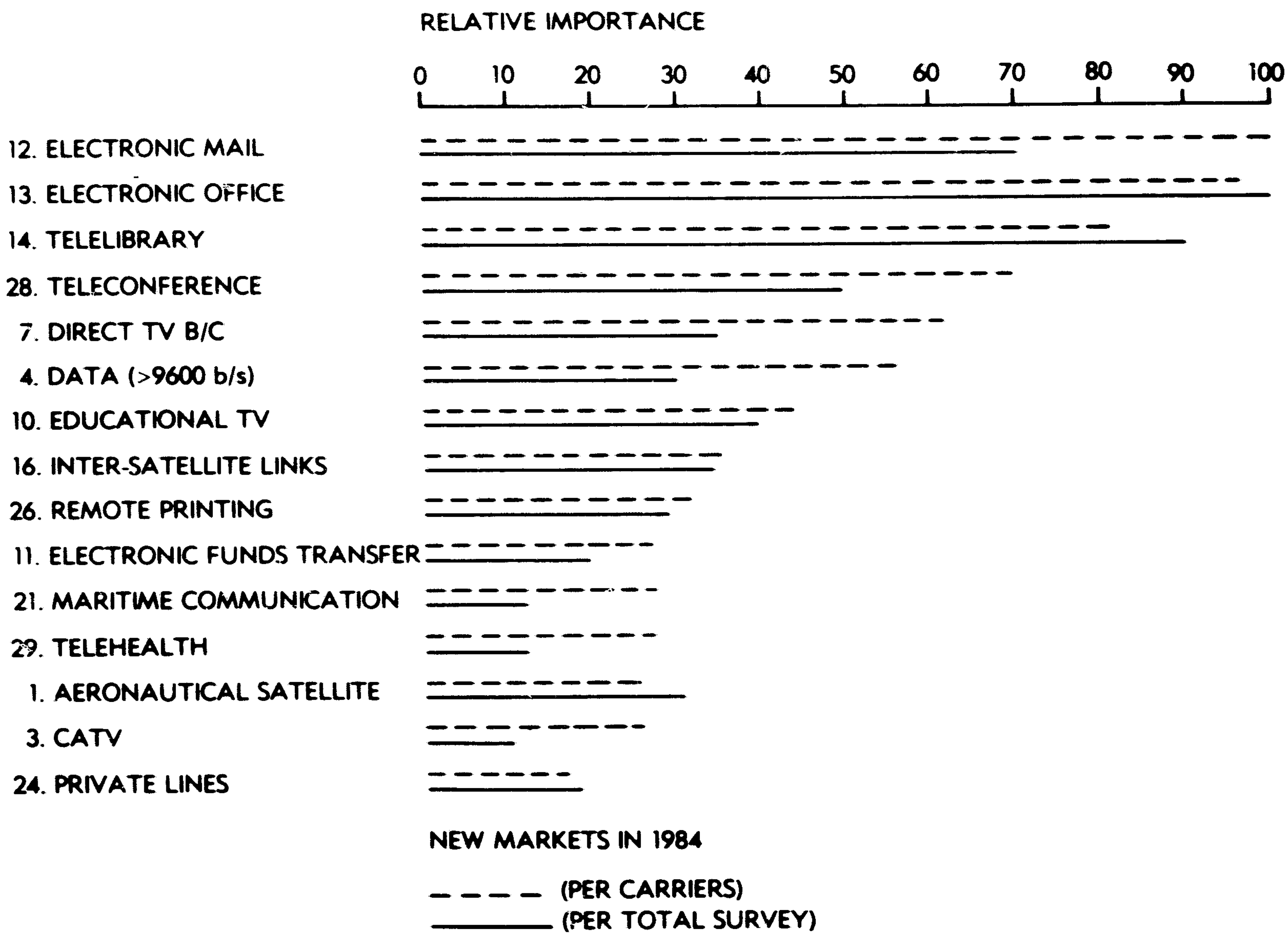
THE CHOICES OF THE CARRIERS WERE SEGREGATED AND COMPARED TO THE TOTAL SURVEY TO TEST THE VALIDITY OF USING THE FULL SURVEY RESULTS. IN GENERAL THE TWO SAMPLES ARE CLOSE AND THUS THE FULL SURVEY RESULTS HAVE BEEN USED.

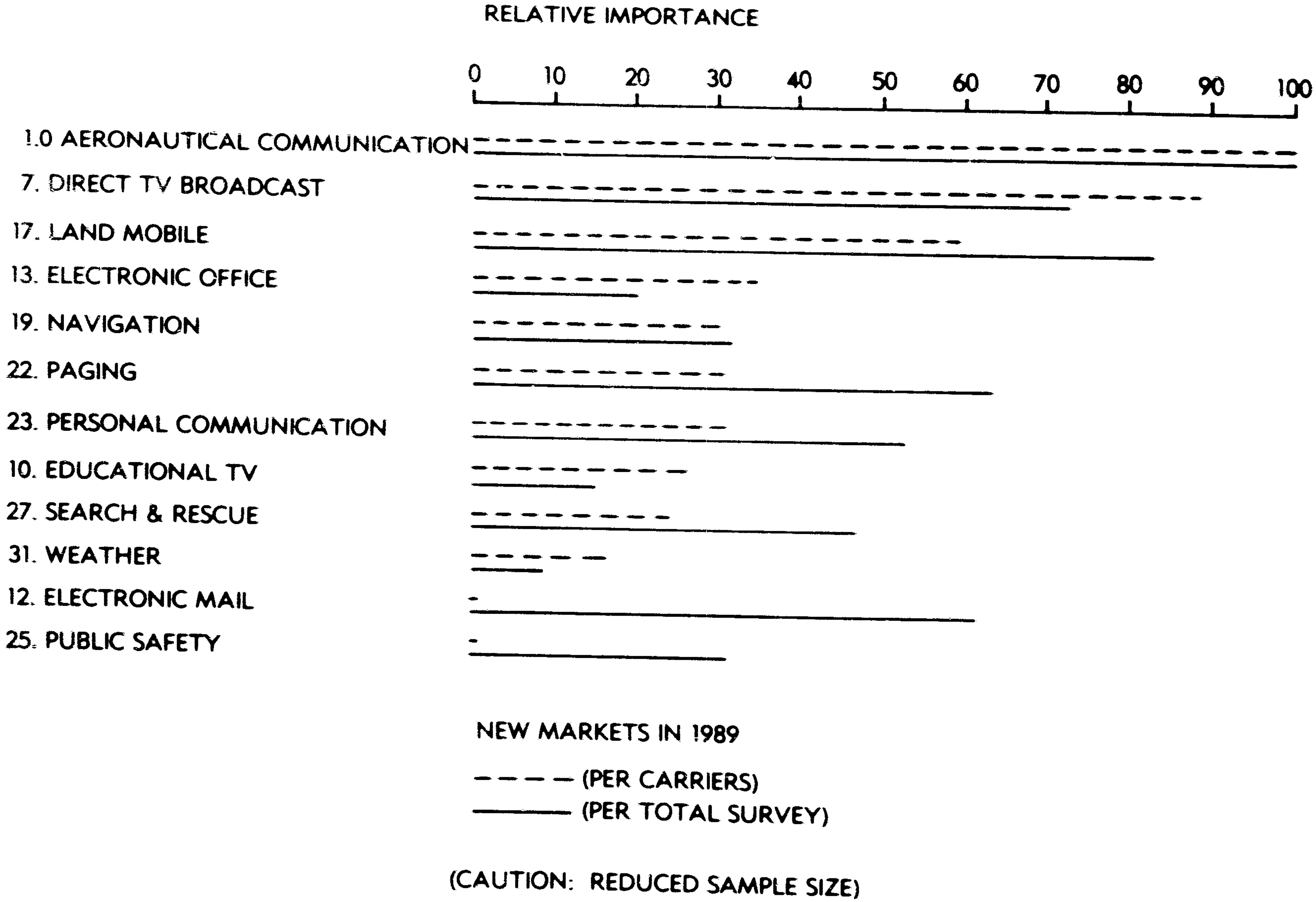
IN 1979 ONLY EXISTING MARKETS ARE SHOWN (A CONTROL CHECK ON THE SURVEY). IN THE CASE OF ELECTRONIC FUNDS TRANSFER (EFT) THIS IS BEING DONE VERY QUIETLY BY THE CARRIERS FOR SUCH BANKS AS BANKWESTERN CORP., BANK OF AMERICA, CHASE MANHATTAN, ETC...LITTLE HAS BEEN SAID IN THE PRESS OF THESE SERVICES, THUS THE LOW RANKING BY NON-CARRIERS.

IN 1984 THE IMPORTANCE OF DIGITAL COMMUNICATIONS IS VERY EVIDENT. MATURED SERVICES (SUCH AS PRIVATE LINES AND CATV) ARE NOT PERCEIVED AS NEW MARKETS.

BY 1989 MOBILE SERVICES ARE ENVISIONED AND A DIVERSION IS NOTED BETWEEN THE TWO GROUPS (AS MIGHT BE ANTICIPATED).


RELATIVE IMPORTANCE
0
10
20
30
40
50
60
70
80
90
100
15. INTERNATIONAL COMMUNICATION
3. CATV
24. PRIVATE LINES
8. TRUNK TELEPHONY
20. NETWORK TV
31. WEATHER
6. DEFENSE
9. EARTH EXPLORATION
4. DATA (>9600 b/s)
11. ELECTRONIC FUNDS TRANSFER
21. MARITIME COMMUNICATION
26. REMOTE PRINTING
1979 MARKETS
(PER CARRIERS)
(PER TOTAL SURVEY)


RELATIVE IMPORTANCE
0
10
20
30
40
50
60
70
80
90
100
12. ELECTRONIC MAIL
13. ELECTRONIC OFFICE
14. TELELIBRARY
28. TELECONFERENCE
7. DIRECT TV B/C
4. DATA (>9600 b/s)
10. EDUCATIONAL TV
16. INTER-SATELLITE LINKS
26. REMOTE PRINTING
11. ELECTRONIC FUNDS TRANSFER
21. MARITIME COMMUNICATION
29. TELEHEALTH
1. AERONAUTICAL SATELLITE
3. CATV
24. PRIVATE LINES
NEW MARKETS IN 1984
(PER CARRIERS)
(PER TOTAL SURVEY)


RELATIVE IMPORTANCE
0
10
20
30
40
50
60
70
80
90
100
1.0 AERONAUTICAL COMMUNICATION
7. DIRECT TV BROADCAST
17. LAND MOBILE
13. ELECTRONIC OFFICE
19. NAVIGATION
22. PAGING
23. PERSONAL COMMUNICATION
10. EDUCATIONAL TV
27. SEARCH & RESCUE
31. WEATHER
12. ELECTRONIC MAIL
25. PUBLIC SAFETY
NEW MARKETS IN 1989
(PER CARRIERS)
(PER TOTAL SURVEY)
(CAUTION: REDUCED SAMPLE SIZE)

MARKET SHARE IN 1984

THE PEOPLE SURVEYED WERE ASKED TO ESTIMATE THE PERCENT OF THE TOTAL MARKETPLACE THAT WOULD BE SERVED BY SATELLITES IN 1984. THEY WERE GIVEN A SET OF CARDS WITH 1%, 5%, 10%, 25%, 50%, AND 99% WRITTEN ON THEM. THEY WERE THEN ASKED TO SORT THE 31 SERVICE CARDS AMONG THESE 6 ESTIMATES OF THE AMOUNT OF TRAFFIC CARRIED BY SATELLITE IN 1984.

A. VOICE

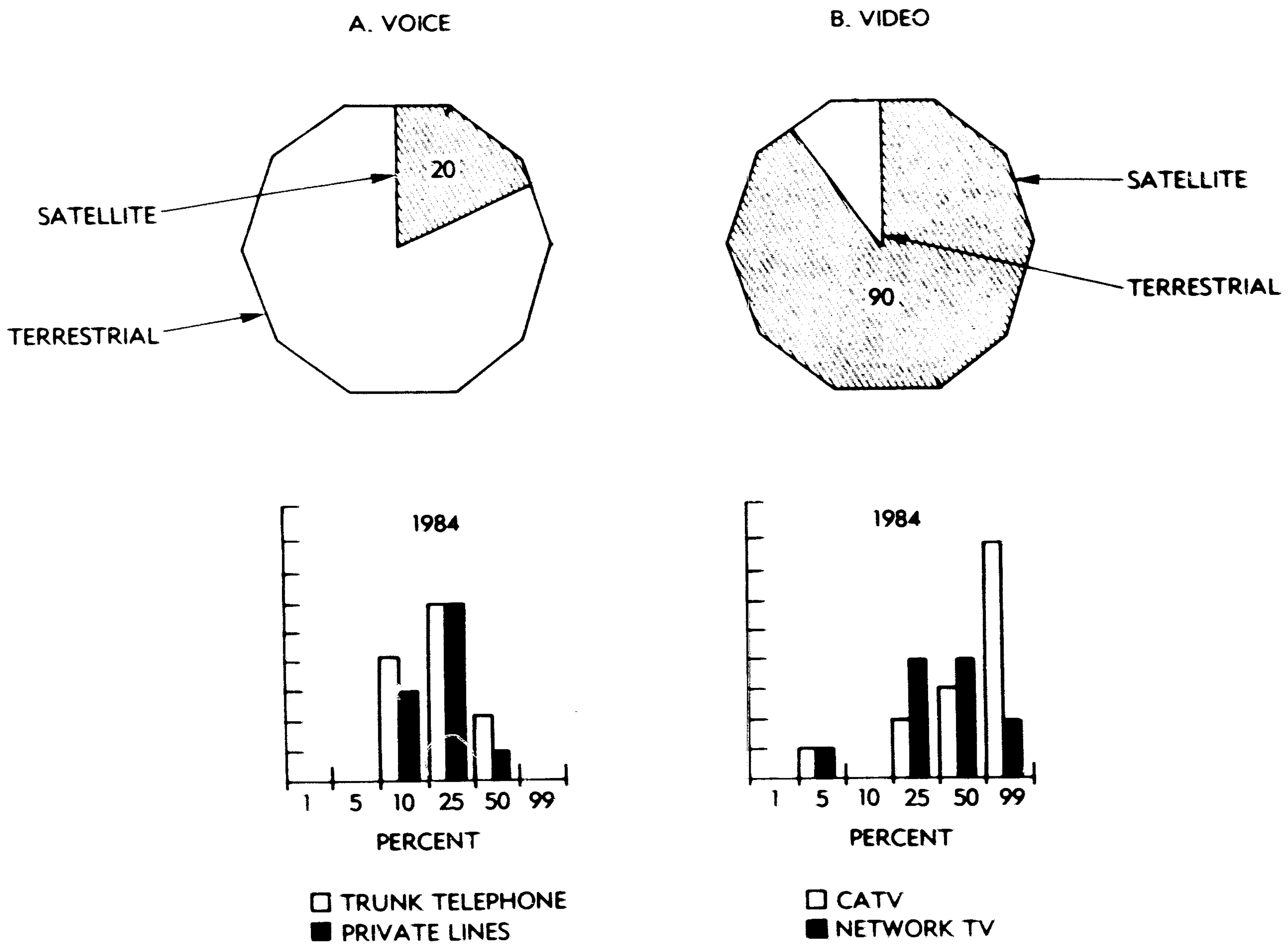
THE BAR CHART SHOWS THE DISTRIBUTION OF ANSWERS FOR BOTH TRUNK TELEPHONY (UNSHADED) AND PRIVATE LINES (SHADED). THE ESTIMATES FOR BOTH TYPES OF TRAFFIC PEAKED AT 25% IN 1984. JUDGING FROM THE NUMBER OF 10% AND 50% RESPONSES, I WOULD ESTIMATE THAT SATELLITES WILL SERVE APPROXIMATELY 20% OF THE TOTAL MARKETPLACE IN 1984. IN 1979 THEY SERVE ABOUT 5% OF THE TOTAL MARKETPLACE WITH THE REMAINDER BEING SUPPLIED BY TERRESTRIAL MEANS. BY 1989 I WOULD ESTIMATE THAT THE SATELLITE SHARE SHOULD GROW TO 25%.

B. VIDEO

B. VIDEO ENCOMPASSES BOTH THE CATV AND THE NETWORK TV SERVICES. HERE WE SEE A LARGE PEAK IN THE 99% FOR CABLE TV IN 1984. THE NETWORK TV, HOWEVER, SEEMS TO PEAK SOMEWHERE BETWEEN 25 AND 50%. CONSIDERING THAT THERE ARE MANY MORE CABLE TV TRANSPONDERS THAN NETWORK TV TRANSPONDERS, THE WEIGHTED AVERAGE RESULTS IN ANY ESTIMATE OF 90% OF THIS TYPE OF VIDEO GOING BY SATELLITE BY 1984.

TODAY A LITTLE LESS THAN HALF OF THE TOTAL TRAFFIC FLOWS BY SATELLITE. BY 1989 I WOULD ESTIMATE THAT SATELLITES WILL SERVE APPROXIMATELY 97% OF THIS MARKETPLACE.

MARKET SHARES



C. VIDEO

EDUCATIONAL TV WAS JUDGED TO BE SOMEPLACE IN THE 10 TO 50% RANGE WITH MORE RESPONSES IN THE 10% THAN IN THE 50% RANGE. CONSEQUENTLY, IT APPEARS THAT 20% OF THE MARKETPLACE WILL BE SERVED IN 1984.

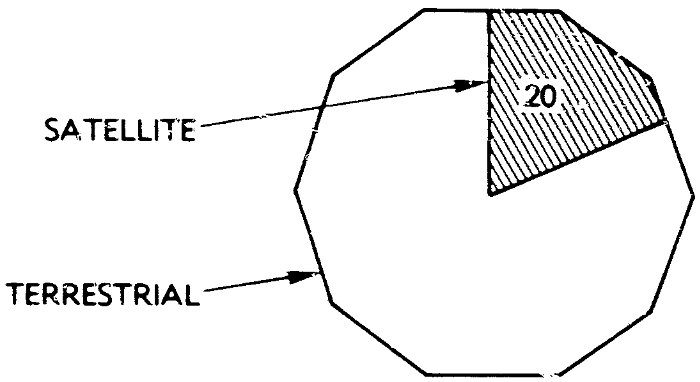
TODAY ESSENTIALLY NONE OF THIS MARKET IS SERVED (WITH THE EXCEPTION OF THE PUBLIC BROADCASTING SYSTEM WHICH IS INCLUDED IN B. VIDEO). BY 1989 THE SATELLITE SHOULD ACCOUNT FOR ABOUT 35% OF THE TOTAL TRAFFIC.

D. VIDEO

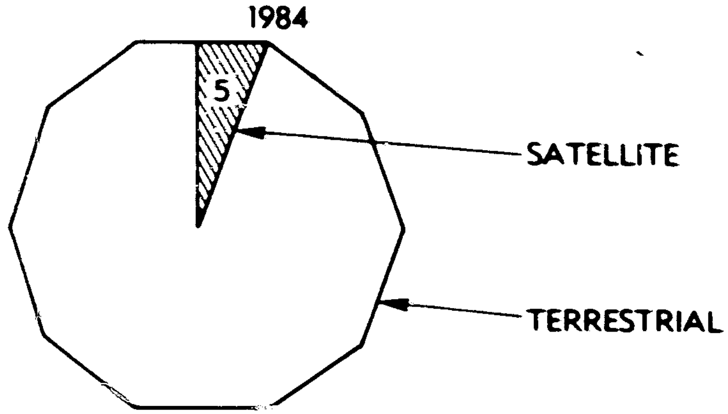
DIRECT TV BROADCAST HAS BOTH ITS FOES AND ITS FRIENDS, AS SHOWN IN THE BAR GRAPH. AT THE TIME OF THE SURVEY FEW FELT IT WOULD BE A SUBSTANTIAL ENTITY BY 1984. CONSEQUENTLY, I HAVE SHOWN A 5% SLICE FOR THIS TYPE OF TRAFFIC IN 1984.

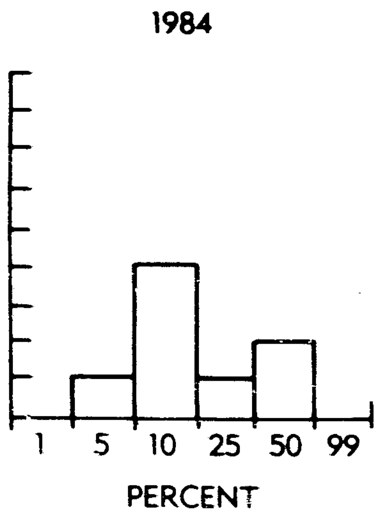
MARKET SHARES

C. VIDEO

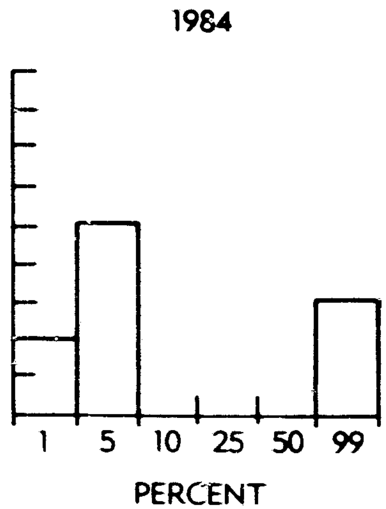


D. VIDEO





EDUCATIONAL TV



DIRECT TV BROADCAST

E. DATA

E. DATA (GREATER THAN 9.6 KBIT/S IS SHOWN TO BE PEAKING AT 25% IN THE BAR GRAPHS. THE ELECTRONIC FUNDS TRANSFER (BANK TO BANK TRANSACTIONS, ETC.) WAS FAIRLY UNIFORM IN THE 5 TO 50% RANGE. CONSEQUENTLY, E. DATA IS SHOWN AS APPROXIMATELY 10% BY 1989.

TODAY, VERY LITTLE DATA FLOWS BY SATELLITE (PROBABLY AROUND 1 OR 2%). HOWEVER, THE MARKETPLACE IS RELATIVELY SMALL. BY 1984, 10% WILL BE FAIRLY SIGNIFICANT AND BY 1989 THIS MAY GO INTO THE 35% RANGE.

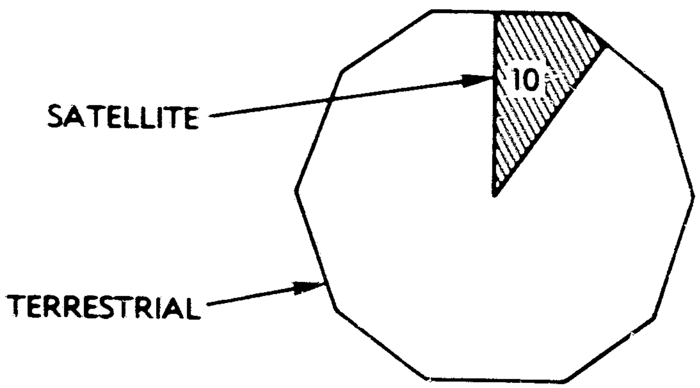
F. DATA

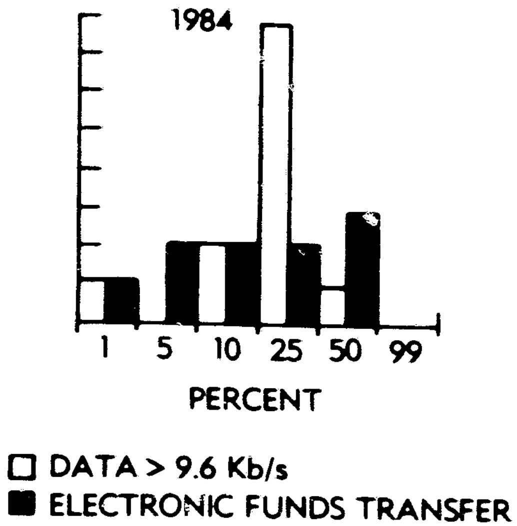
THE FIVE TYPES OF F. DATA ARE SHOWN BELOW THE BAR CHART. THERE IS A PEAK IN THE 25 AND 50% REGIONS WHICH LEADS TO THE CONCLUSION THAT THE 1984 TRAFFIC WILL BE ABOUT 35% OF THE TOTAL AVAILABLE.

TODAY VERY LITTLE SATELLITE SERVICE IS AVAILABLE, AND SATELLITES REPRESENT A VERY SMALL PERCENTAGE. BY 1989 MORE THAN HALF OF THE TRAFFIC (ABOUT 55%) WILL FLOW VIA SATELLITE.

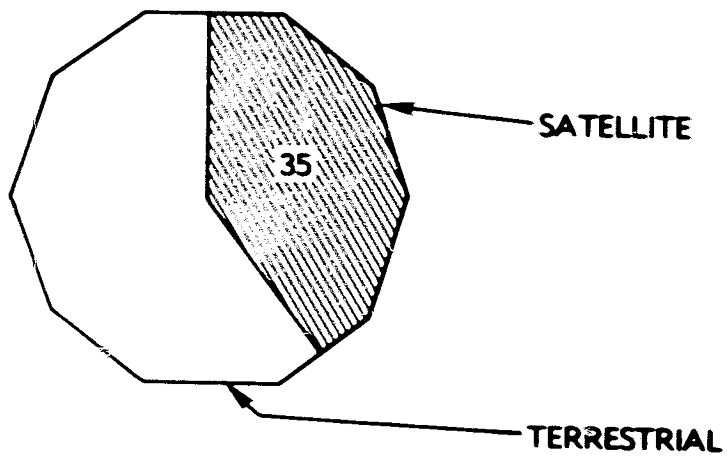
MARKET SHARES

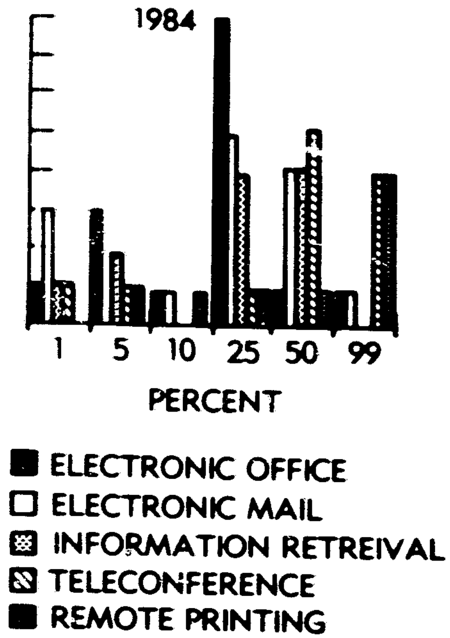
E. DATA





F. DATA





G. AERONAUTICAL MOBILE SATELLITE

A WIDE VARIETY OF ESTIMATES WERE OBTAINED FOR THIS PARTICULAR CASE BUT I HAVE SHOWN A ZERO ESTIMATE FOR 1984 BECAUSE THERE IS NO AERONAUTICAL OR NAVIGATION SATELLITE PRESENTLY UNDER DESIGN FOR THE GEOSYNCHRONOUS ORBIT.

PRESENTLY NEITHER OF THESE SERVICES IS SERVED BY SATELLITE (WITH THE EXCEPTION OF FEW ISOLATED MILITARY EXAMPLES). BY 1989 THE MARKET WILL CHANGE SUBSTANTIALLY AND SATELLITES MAY PROVIDE APPROXIMATELY 25% OF THE CLASS G SERVICE.

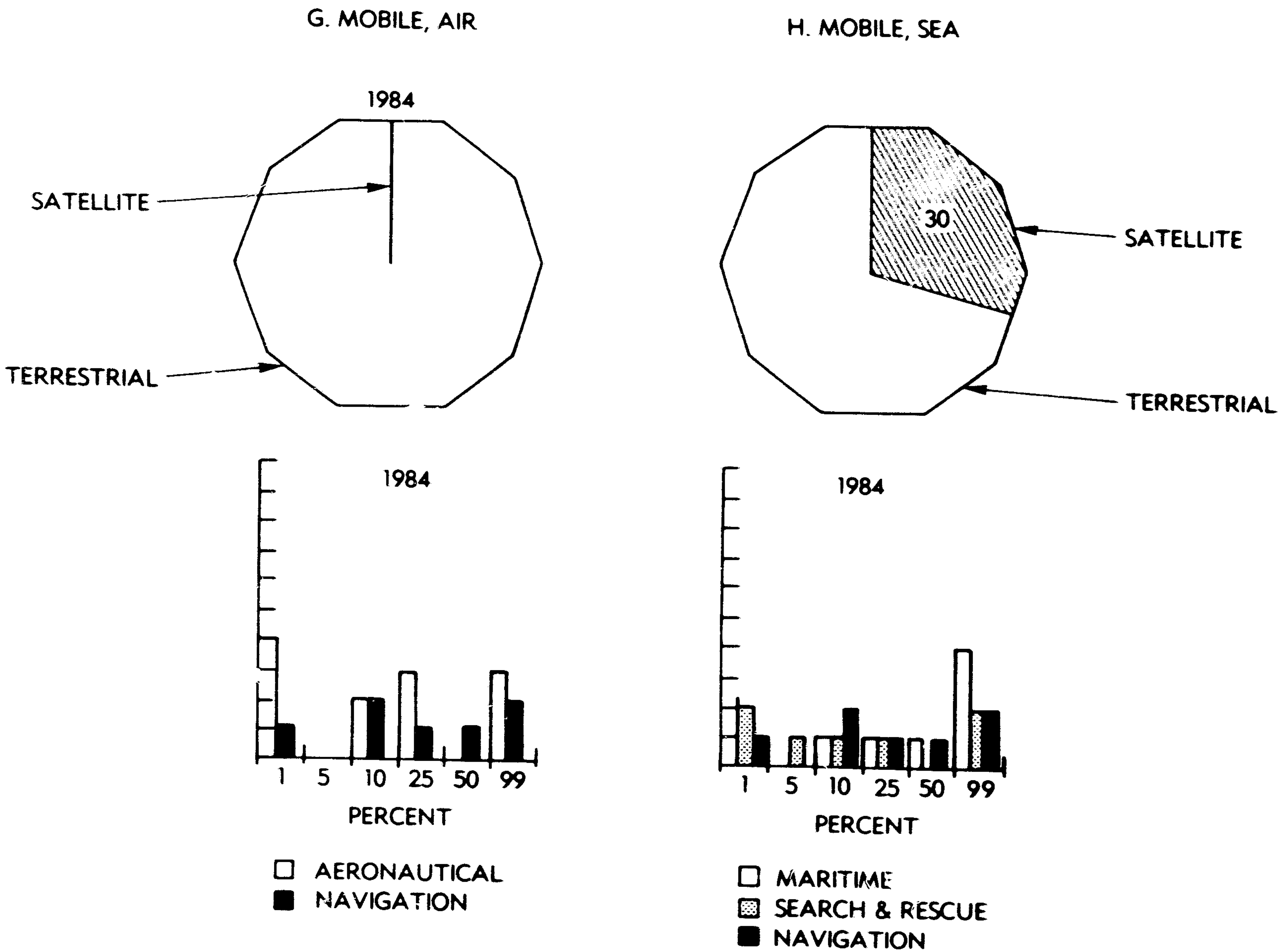
H. MARITIME MOBILE SATELLITE

BY 1984 IT IS ESTIMATED THAT THE MARISAT AND INMARSAT TYPES OF SERVICES WILL ACCOUNT FOR APPROXIMATELY 30% OF THE WORLDWIDE MARITIME SHIP COMMUNICATIONS (TO REASONABLY LARGE SHIPS).

AT PRESENT ABOUT 10% OF THE TOTAL TRAFFIC IS CARRIED BY SATELLITE AND THE REMAINDER BY HIGH FREQUENCY MORSE CODE AND SIMILAR SERVICES. BY 1989 I PREDICT A SUBSTANTIAL CHANGE WHEREIN ABOUT THREE-FOURTHS OF THE TRAFFIC IS CARRIED BY SATELLITE.

THE BAR GRAPH SHOWS A NUMBER OF PEOPLE WHO FEEL THAT THE MARITIME SERVICE WILL BE 99% BY 1984. I DO NOT SHARE THEIR OPTIMISM. THIS SERVICE ALSO INCLUDES SEARCH AND RESCUE AND MARITIME NAVIGATION.

MARKET SHARES



I. LAND MOBILE

IT IS ESTIMATED THAT 5% OF THE LAND MOBILE TRAFFIC MAY GO BY SATELLITE IN 1984 BASED ON THE USER SURVEY.

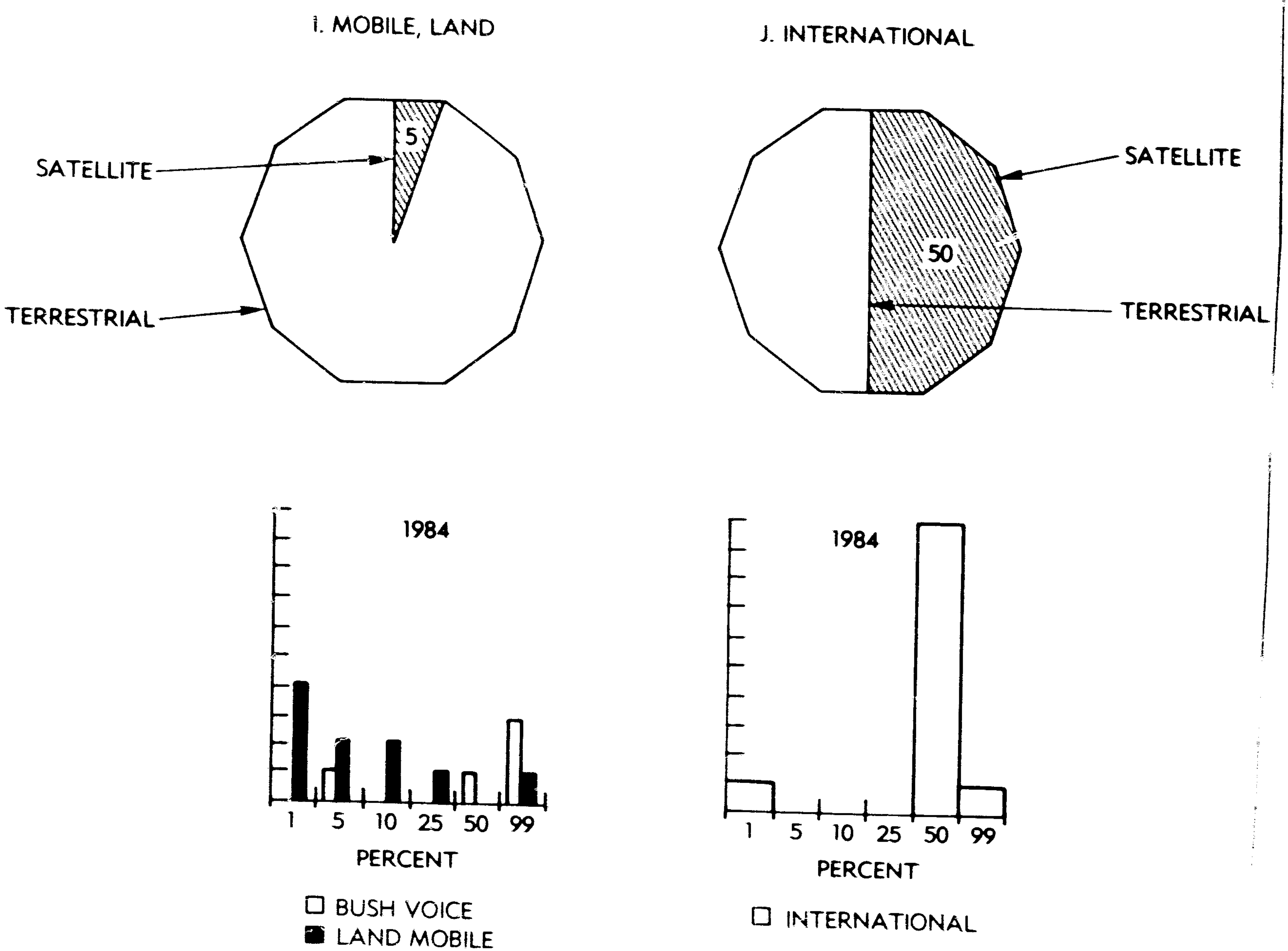
TODAY THERE ARE NO LAND MOBILE SERVICES VIA SATELLITE TO SPEAK OF, AND THEREFORE THE PERCENTAGE IS APPROXIMATELY 0%. BY 1989 THIS MAY GROW TO ABOUT 15%. CONSIDERING THE LARGE NUMBER OF LAND MOBILE TRANSMITTERS, LICENSED AS SUCH, PLUS THE CITIZEN'S BAND TRANSMITTERS BEING USED FOR THIS SERVICE, 15% IS A RATHER SIZABLE NUMBER OF CIRCUITS.

J. INTERNATIONAL

THE CORRECT ANSWER FOR 1979 IS 50%. THE ESTIMATE OF 50% FOR 1984 IS CONSISTENT WITH THE AGREEMENTS AMONG THE CARRIERS.

BY 1989 A FIBER OPTIC CABLE MAY WELL HAVE BEEN LAID ACROSS THE ATLANTIC OCEAN, AND THE TERRESTRIAL SHARE MAY INCREASE AT THE EXPENSE OF SATELLITES WITH SATELLITES REPRESENTING ONLY 40% OF THE TOTAL MARKETPLACE. WE SHOULD RECOGNIZE, HOWEVER, THAT THIS IS A MARKETPLACE THAT IS GROWING AT ABOUT 20% PER YEAR.

MARKET SHARES



K. INTERSATELLITE LINKS

THIS QUESTION WAS INTERPRETED TWO DIFFERENT WAYS. SOME PEOPLE FELT THAT TRAFFIC WOULD CONTINUE TO FLOW VIA THE EXISTING TERRESTRIAL STATIONS THROUGH DOUBLE HOPS. ANOTHER GROUP FELT THAT INTERSATELLITE LINKS WERE INEVITABLE, AND THAT THEY HAD ALREADY BEEN PROVEN ON THE LES-8 AND -9 SATELLITES AND COULD INDEED BE IN PLACE BY 1984. RECOGNIZING THE LEVEL OF PLANNING IN 1979, I WOULD ESTIMATE THAT A MAXIMUM OF 5% OF THE OCEAN-TO-OCEAN TRAFFIC MIGHT GO VIA AN INTERSATELLITE LINK IN 1984.

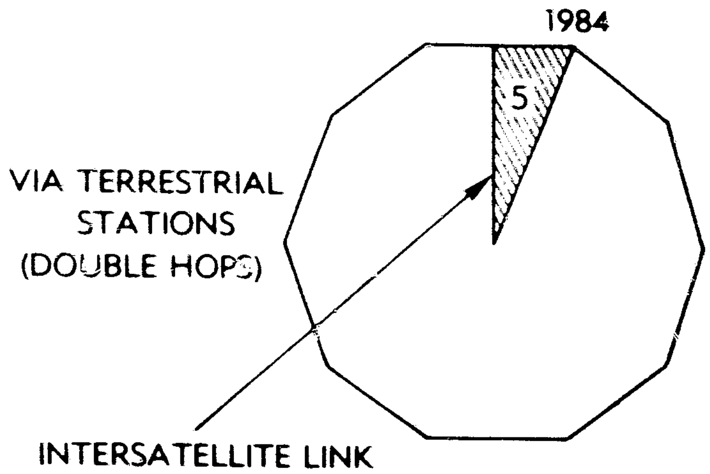
TODAY NO TRAFFIC GOES BY AN ISL, BUT BY 1989 THE INTERSATELLITE LINK MAY CAPTURE ABOUT 40% OF THE POTENTIAL TRAFFIC.

L. WEATHER

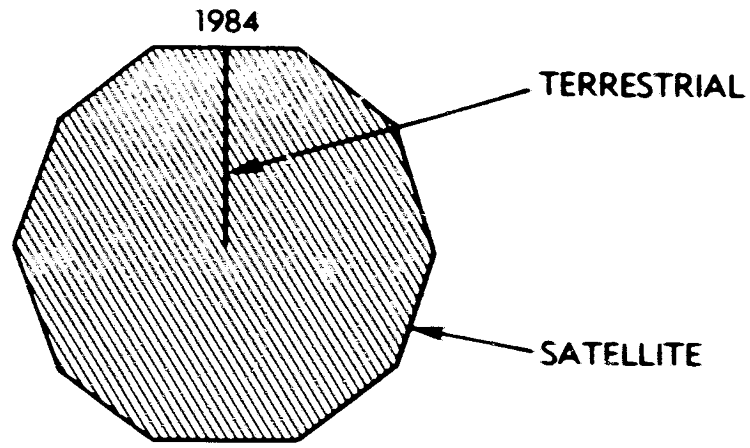
MOST OF THE OBSERVERS INDICATED THAT THEY FELT THAT WEATHER INFORMATION WAS ALREADY BEING OBTAINED ALMOST EXCLUSIVELY BY SATELLITES. THE ESTIMATES FOR 1979, 1984, AND 1989 ARE ALL APPROXIMATELY 100%.

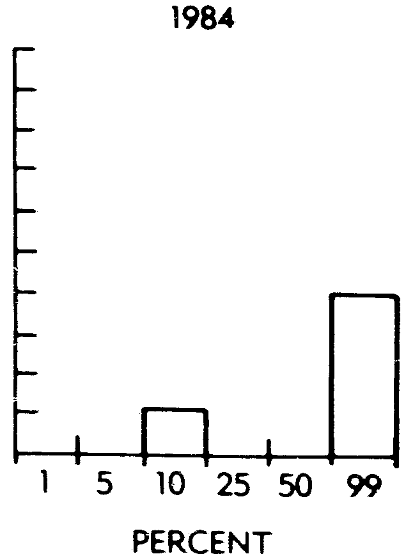
MARKET SHARES

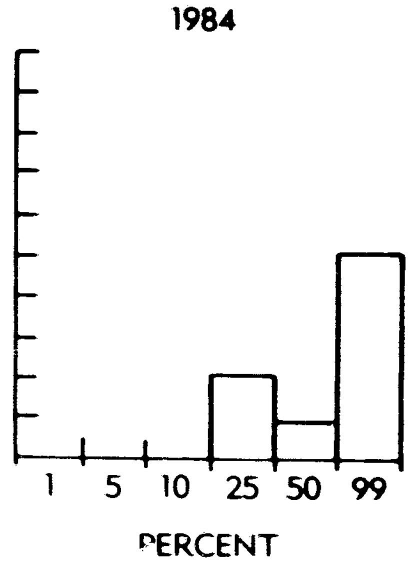
K. INTERSATELLITE LINKS



L. WEATHER







NASA—MSFC—C